AGRICULTURAL ENGINEERING

Established 1920

This journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

SUBSCRIPTION PRICE: To non-members of the A.S.A.E., $3.00 a year in the U. S. and possessions and in Americo-Spanish countries, $3.50 a year in Canada, and $4.00 a year in all other countries; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

CONTENTS FOR OCTOBER 1940

Volume 21, Number 10

EDITORIALS

Agricultural Research Functions

IT is clear, as indicated in the address by R. W. Trullinger (published in this issue), that the public is not and probably never will be ready to sign a blank check to finance research in pure science for the incidental benefits to agriculture which might result. Research in pure science is publicly supported in the interest of scientific and educational progress, but not as part of the program of agricultural research. For the money it allocates to agricultural research, the public wants a direct, vigorous, and effective pursuit of answers to important practical agricultural problems.

Mr. Trullinger indicates that agricultural engineers should be in on the planning, as well as the execution of agricultural research, not to push for projects involving agricultural engineering exclusively, but with a cooperative spirit, to contribute a viewpoint on the nature and importance of various agricultural problems; to pick out and make known the parts or phases of general problems which agricultural engineering technology might help to solve; and, if we read between the lines correctly, to point out basic data needed by agricultural engineers which might best be provided by other specialists.

These demands upon agricultural research—that its recommendations must be economically applicable; that its biological aspects must recognize physical variables; and that it must answer many of its own questions as to physical principles and data—give agricultural engineering its place and opportunity in agricultural research planning and execution.

Refinement of Grass Silage Economy

NOW that grass silage has proven almost as popular with farmers as the pleasure car and the county fair, its processing and storage are due for some engineering refinement. In the aggregate, it is a mass production proposition, and a few cents a ton cut from costs or added to value of product in various ways will mean thousands of dollars to American farmers.

Refinement in the engineering of grass silage production must be based on clearly defined objectives in terms of nutritional chemistry and economics. Chemically, what is high-quality cow-kraut, and how and to what extent is it influenced by physical factors in the growth, harvesting, cutting, and storage of the grass?

As to economy, what nutritional values per acre, per man-hour, per cow, and per dollar of cost can be provided in the form of grass silage, as influenced by type and variety of grass or legume, and time and methods of handling, in comparison with corn silage and with other methods of harvesting and storage of various crops? What are the optimum proportions and quantities of grass silage in the diets of dairy cows and other livestock? How are other feed production and storage requirements influenced? How much livestock must a farmer raise and what must be its grade of productivity to make grass silage profitable?

Obviously, agricultural engineers will want to cooperate with farm crop and animal nutrition specialists to get the answers to some of these questions.

Whatever the architectural and pastoral beauty of the silo, farmers are interested in it primarily from the standpoint of production economy. To most fully serve this interest, and the related interest of farm building materials and equipment manufacturers, engineering refinement of grass silage production can logically proceed in several directions.

From a research standpoint it will work toward more accurate determination of nutritional objectives and of mechanical, structural, and farm practice principles contributing to realization of those objectives. With these it will work toward more complete data and principles on the production engineering or economics of grass silage, particularly as influenced by equipment and practices used in crop culture, harvesting, and ensiling; silo construction principles, costs, and durability; and the interrelations of silage quantity requirements, operating methods, equipment, silo construction, and costs.

From an extension or service standpoint it will coordinate and make available to farmers and manufacturers the latest and best information as to results that can be expected from various practices, equipment, and types of construction, and as to the range of opportunity for economical grass silage production.

From a commercial development standpoint it will seek to provide structural materials and designs, equipment improvements, and related farm practices which will improve silage quality, lower costs, and make the advantages of grass silage available to smaller farms and wider areas.

In response to agricultural engineering interest in refining the engineering of grass silage production, a joint session will be devoted to the subject by the Farm Structures and Power and Machinery Divisions at the fall meeting of the American Society of Agricultural Engineers in Chicago, early in December. This should serve to consolidate information on progress to date, draw attention to any weak points in its engineering, picture promising opportunities for engineering refinement, and stimulate effective action toward developing the full possibilities of grass silage.

Heat Liberated by Hens

To the Editor:

IN the article, entitled "Adapting Ventilating Fans to Farm Buildings and Equipment," by H. N. Stapleton, appearing in AGRICULTURAL ENGINEERING for September 1940, the figure of 185 Btu per day per hen is used as the amount of heat liberated. In checking this with other data published in AGRICULTURAL ENGINEERING, the figure seemed out of line, so I wrote Mr. Stapleton and he has suggested that I write you in regard to it.

According to the article, entitled "Heat Production of Poultry under Housing Conditions," by Henry Giese, in AGRICULTURAL ENGINEERING for March 1933 (vol. 14, no. 3), the amount of heat liberated per bird varies considerably with the environment in which the hen is placed. The illustration used in Mr. Giese's article shows the amount of heat lost by bird exposed to various temperatures and in pens with varying thermal coefficients. Reference to this illustration is desirable in attempting to give a definite figure for the heat production of hens, because it shows how the heat production varies under different conditions.

I should also like to refer agricultural engineers to an article by H. H. Mitchell and M. A. R. Kelley in the 1933 Journal of Agricultural Research (U.S.D.A.), vol. 47 pages 735-748.

G. R. SHIER

Extension agricultural engineer
Ohio State University.

AGRICULTURAL ENGINEERING

VOLUME 21 OCTOBER 1940 NUMBER 10

Why and How Agricultural Research Involves Agricultural Engineers

By R. W. Trullinger
FELLOW A.S.A.E.

THERE was a time when engineers wishing to apply their technical knowledge to the practices and problems of agriculture were at a loss to know how to proceed. In the early years of agricultural engineering, therefore, it was not strange that members of the profession asked for guidance, frequently of a detailed character, particularly when confronted by problems the answers to which could be obtained only through research.

With the passing of the years, however, agricultural engineers have learned to cultivate essential agricultural contacts and to develop techniques peculiar to the profession. The result has been that less is heard nowadays about agricultural engineering research and more about agricultural research in which engineers are participants. Considering the developments of recent years in land-use planning, soil and water conservation, discoveries of new technical and industrial uses of agricultural products and by-products, and improvements in commodity production, processing, and marketing, it is probable that there are more agricultural engineers employed in the various phases of agricultural research than ever before. This would seem to indicate that through constructive development of the profession along lines of technical service to the industry to which it is attached, agricultural engineering has gradually assumed its logical place in agricultural research as one of the recognized essential technical tools.

In consequence, present-day administrators of agricultural research no longer think of agricultural engineering as something which needs to be nursed, nurtured, and guided to the extent that perhaps was necessary in former times. It is looked upon rather as a technical science capable of standing upon its own feet and of participating in agricultural investigations on the same basis as the other essential sciences, such as chemistry, physics, bacteriology, economics, etc.

For the purposes of this discussion, therefore, it is proposed to dispense with consideration of professional development and to concentrate for the moment on why and how agricultural engineering technique, already largely developed and tested by time, may become an important essential in the solution of agricultural problems. This line of thinking would seem to offer greater opportunities for additional agricultural engineers to become research workers than if notice were confined merely to the development of professional techniques without clear industrial objectives.

In order to clarify the picture as much as possible it seems desirable to examine not only some of the technical aspects of agricultural research but, more particularly, some of the important administrative and organizational phases. A brief development of this picture may tend to show why proper orientation and modernization of their thinking is likely to be helpful in bringing engineers into agricultural research and how they should direct their energies so as to be most effective when they get there.

It seems important to know at the outset (1) why agricultural research is necessary, (2) who conducts it, and (3) who pays for it. The first question is answered briefly in a statement[1] recently made by the Secretary of Agriculture. The Secretary said, "The activities of the Department of Agriculture constitute one broad program for all agri-

An address before the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. The author is assistant chief, Office of Experiment Stations, U. S. Department of Agriculture.

[1]Hearings, Committee on Appropriations, U. S. Senate, Subcommittee on H. R. 8202, 76 Cong, 3 Sess, p 63.

Agricultural engineering research in field crop production is logically a matter of applying the technology wherever and however it may show the way to increased net human satisfaction. It must be correlated with the sciences concerned with the crop, its parasites, the soil on which it grows; and the uses to be made of the crop

culture. The scientific work of the Department is a basic part of this program. From a long-time standpoint this work is absolutely vital and necessary. Unwise curtailment of scientific work is bound to reflect itself in increased production costs, increased losses, and consequent inability to produce cheaply or efficiently. The failure of the Department . . . to do necessary research is bound to hinder every Department program. Immediate budgetary savings at the expense of Department research run the risk of costing both farmers and consumers heavily in the long run."

MOST AGRICULTURAL RESEARCH PUBLICLY SUPPORTED

The Secretary pointed out that private industry can do its own research because of the resources of great corporations. He went on to say, however, that "most farms are small and most farmers poor. If adequate agricultural research is to be done, government must help do it." The answer to the second question, "Who conducts agricultural research?" is therefore that most of the agricultural research now current is being conducted by the bureaus of the U. S. Department of Agriculture and by the state agricultural experiment stations. The current program of agricultural research at these institutions is broad as to subject matter, covering a multitude of economically important practical problems in the varied phases of agricultural commodity production, processing, and marketing and related rural life subjects as they arise in the more than 775 different type-of-farming areas of the United States.

It follows, therefore, in answer to the third question, "Who pays the bill?", that most of the agricultural research now current is financed by public funds made available for the purpose by federal and state legislation. Because of the fact that provision of research funds by legislation is usually based upon well-established needs for research services to major groups of farmers and organized groups of other citizens, such funds are generally circumscribed by instructions and limitations as to their use. Thus the public, through legislation, determines the character and scope of the research to be conducted, specifies the major research agency which shall carry it out, and provides the necessary funds. The research agency or agencies, whether federal or state or both, conduct the investigations thus ordered and do so within the legal authority and limitations imposed.

These facts as to the mechanism of publicly supported agricultural research imply strict accountability for the proper productive use of research funds. They indicate why a public research agency must have an overall administrative officer who is responsible for the character, scope, and success of the research program and for seeing that it complies with legislation governing the institution and its work. These facts also indicate to a certain degree why and wherein a publicly supported research institution may differ from one that is privately endowed. Whereas in privately endowed organizations broad authority frequently exists to expend funds and time on major abstract subjects which may ultimately become of great usefulness to the public, in government supported research institutions, the job is usually to meet pressing and practical field problems with tangible information of substantial, useful, and permanent character within a reasonable period of time. More often than not the practical field problem is identified by the agricultural extension service and brought to the experiment station for solution. It seems unnecessary to emphasize that the solution must be sound, complete, permanent, and practical, and by all means prompt if it is to be put to useful field application.

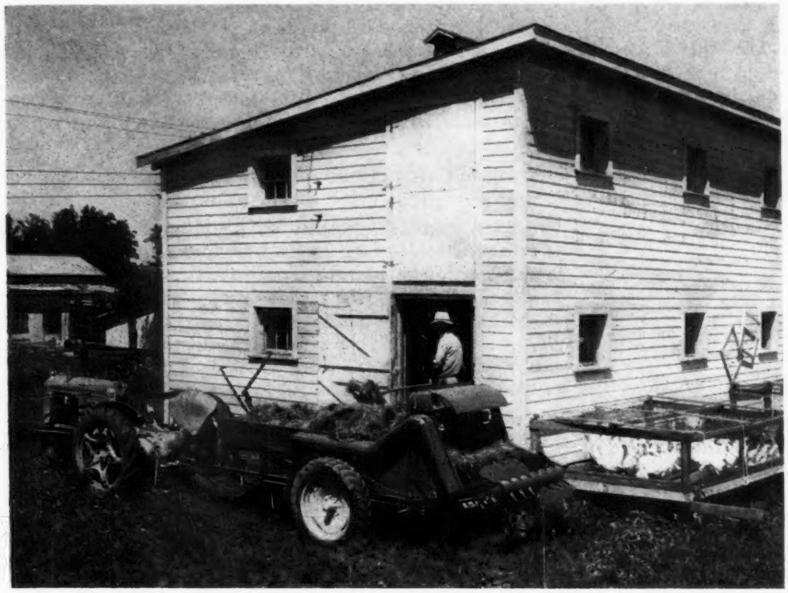
For example, certain privately endowed research agencies have in the past engaged in extended studies on the major abstract subject of the physics of light. Such research has required considerable freedom of procedure in the expenditure of time and money, and usually has not been encumbered with the necessity of producing results within any time limitations or of accounting for funds expended in terms of tangible results. No one questions the fact that the results of this and similar types of investigation have been of broad usefulness to the public, and the very character of the research has necessitated the environmental conditions described. However, the situation is quite different where research is being conducted for the benefit of a major production industry such as agriculture, which operates under definite economic as well as seasonal requirements and limitations. If, for example, a disease or insect pest of cantaloupes, sweet potatoes, or pecans is encountered which threatens to destroy these crops in a state where they are of major importance, the public research agency is expected to mobilize its pertinent scientific and technical resources in an effort, consistent with other needs, to find out how to reduce the threatened losses to a minimum as quickly, effectively, and economically as possible. This may include, for example, the development of mechanical equipment specifically adapted to the proper application of insecticidal or fungicidal sprays, dusts, or gases to these crops.

In brief, the farmers concerned must have service in the form of prompt and tangible information if their pressing and economically important problems are to be effectively met. Farmers expect the extension specialist to perform his advisory duties with accuracy and precision, and he in turn has a right to demand the same consideration from his research associates. Under such circumstances, therefore, it has become necessary to adopt rather rigid and definite criteria for agricultural research supported by public funds and to place it under strict and authoritative direction.

RESEARCH IN THE AGRICULTURAL EXPERIMENT STATIONS

Since a large part of the membership in the American Society of Agricultural Engineers comes from the land-grant colleges and universities, it may be well to limit further discussion to the state agricultural experiment stations which are departments of these institutions. While the responsibilities of federal department bureaus and of agricultural experiment stations differ somewhat as regards scope of research activities and of applicability of results, they are similar in overall objectives, general organization, and scientific substance. Both are concerned with basically sound research aimed at the permanent solution of farming problems which they have been commissioned by the public to secure. For obvious reasons the research efforts of the two agencies are highly coordinated, which in fact is required by law. The experiment station, however, is a more typical research agency for the purposes of this discussion because it is organized primarily to serve the entire agricultural industry of the state in which it is located.

The first state agricultural experiment station was described by its director as an institution where the rigid tests of scientific experiment could be used for gaining a more certain understanding of the principles underlying the right practice of agriculture. Since the passage of the Hatch Act in 1887, which established a land-grant agricultural experiment station in each state, this definition has been universally adopted. It recognizes the fact that the state agricultural experiment station comprises a compact group of scientists operating on a well-defined research program calculated to solve the problems of farming of the state, the entire procedure being organized and coordinated by a director with the assistance of his scientific staff. The implication is strong throughout the 53 years of operation of



Poultry raising involves not only biological science, but agricultural engineering from the standpoints of housing, electrical equipment, mechanical field and farmyard operations, and cropping and fertilizing practices influencing soil and water conservation. Answering farm problems in poultry production involves the engineering of relating biological possibility to economic feasibility

these experiment stations that their research programs have had certain dominant objectives corresponding to the varying conditions in the different states and territories. The elements of the research programs have usually been built around and focused upon these objectives.

Early agricultural leaders recognized the importance of group action for the success of agricultural research in the experiment stations, and especially where the dominant objectives were clear. In 1883 the director of the first state agricultural experiment station advocated the organization of an effective system of cooperative experiments on the different pertinent problems of agriculture in his state which would utilize the services of all scientists and subject-matter specialists concerned. Likewise, in 1887, the Committee on Experiment Station Work of the Association of American Agricultural Colleges and Experiment Stations recognized the importance of full and frequent intercommunication among the different scientists engaged in attacking the several and varied aspects of an agricultural problem. In line with this thinking it has apparently been the intention from the beginning of experiment station work to apply the policy of cooperation and coordination in the individual station to the fullest degree warranted by the needs of the problems under study and the facilities available. The inference to be drawn from the many official discussions of cooperation and coordination in agricultural research in the experiment stations is that, while the success of research has been thought to depend upon the individuality as well as upon the ability of the men engaged therein, and freedom of research initiative and action have been considered as among its first conditions, it is nevertheless true that effective coordination of the different scientific activities pertinent to an agricultural problem are essential to its most efficient and productive solution.

Early in the history of the land-grant agricultural experiment stations, the Committee on Experiment Station Work became concerned over the difficulties met with in accounting for the proper and effective use of research funds and in the most efficient mobilizing of research talent for vigorous, concentrated, and properly focused attack on important agricultural problems. The Committee was aware of the consequent and growing difficulty of defending research appropriations before budgetary and legislative bodies, and also of the tendency toward lack of soundness and definiteness in research which resulted in limiting the usefulness of its findings. These difficulties were attributed in considerable measure to (1) lack of clear discrimination between investigation, in a strict sense, and routine experimental testing or technical service, (2) lack of definiteness in the purpose and plan of investigations which would provide a dependable justification therefor, based on clearly demonstrable needs, (3) the tendency to take up too large or too broad and indefinite problems, a practice known as "shotgunning", and (4) the proneness for the administration of research to be dispersed along narrow independent lines in subject-matter departments without overall sanction of the experiment station or definite relation to the prevailing organized station program, a practice often referred to as "wildcatting". All of these practices made it difficult to finance research along either efficient or legal lines. Dispersed authority in the organization, planning, conduct, and financing of research was found to be particularly obstructive to fruitful effort and engendered competition between station departments for financial support. The consequent lack of scientific soundness and completeness of attack on problems reduced the usefulness of the results attained.

These and other considerations led eventually to the conduct of experiment station work on the basis of well-defined and well-organized research projects, a practice which has become universally adopted by the stations. In the years since 1900 the research project as the tangible but flexible basic unit of research has proved its value in the administration of productive endeavor by the experiment stations, particularly as it relates to the efficient, legal use of available funds, personnel, and facilities, and as it serves to focus concerted thought and action of all concerned in it.

Concentration of the administration of research in the office of the director, rather than in the subject-matter departments, was a logical accompaniment of the adoption of the project system of research by the experiment stations. Furthermore, continued pressure by the Committee on Agricultural Experiment Station Organization and Policy for clearer and more deliberate planning of research projects which would result in more systematic, orderly, and complete scientific attack on agricultural problems has resulted in a general tightening up in the use of research funds. Greater emphasis has been placed upon the necessity for definite purpose and direction in research. As evidence of their soundness, these policies stood the experiment stations in good stead during the lean years beginning with 1932. With reduced facilities the stations met unprecedented de-

mands for special emergency research in connection with the many essential recovery activities, both state and federal. The fact that the experiment stations met this situation, and at the same time maintained essential high standards for research, has demonstrated beyond question the wisdom of centralized administrative control of agricultural research and research funds, and of scientific teamwork in the solution of agricultural problems.

Having built up this picture of the organization and administrative control of agricultural research, the question arises as to where and how agricultural engineers fit into the scheme. The answer appears to be contained in the fact that agricultural engineers are in no wise different in these respects from other essential scientists such as chemists, bacteriologists, animal and plant pathologists, botanists, economists and other specialists trained in the natural and social sciences. It thus follows that, while centralized control is essential to the formulation, coordination, and conduct of a program of agricultural research, the advice and active assistance of an efficient staff of research workers are also indispensable for the success of these undertakings.

PLANNING AGRICULTURAL RESEARCH AND SPECIALIST PARTICIPATION

Thus the experiment station director, with the advice and assistance of his staff of workers, formulates a program of research projects covering the most important and pressing problems confronting the station and within the limits of available authority and funds. Every member of the scientific staff who participates in the planning function does so from the outset of consideration of a problem. This procedure has been found not only to make for well-defined and well-balanced research projects but also to insure cooperation within the experiment station as the needs of a particular research project warrant. It analyzes responsibility into its various elements and places it where it belongs. Investigations are thus planned and developed around problems and objectives rather than around individuals or subject-matter departments. It is also possible by such procedure to set up financial budgets for research which cover the needs of the different projects rather than of participating subject-matter departments, but which at the same time give due consideration to the needs of these departments in so far as is commensurate with their contribution to the prosecution of the different research projects. This aspect assumes major importance when it is considered that funds available for research are nearly always limited in amount and are frequently inadequate to finance research on anything beyond the most pressing problems. Obviously it is incumbent upon the station director to stay within his budget and to utilize his available funds to the greatest advantage.

It thus becomes evident that in agricultural research there are no subject-matter department rights or prerogatives. The origin and character of the research and the limitations imposed upon the use of funds preclude the possibility of recognizing the prior rights of anybody or anything beyond the problems and objectives of the research to be done. Permanent endowments to any subject-matter department embodying authority to conduct research of its own selection, independently of the regularly organized research program and not related thereto, are simply not in the picture of agricultural research as supported by the taxpayers' money.

However, the gate for participation in agricultural research is wide open to those subject-matter specialists who are willing to accept the conditions and limitations imposed and to approach the problems in a constructive manner. This can be amply demonstrated for engineers by an examination of the current research programs of the agricultural experiment stations. While it is true that the label of agricultural engineering rarely appears on research projects, the character and scope of many of them, together with the personnel involved, indicate wide participation by this group of workers.

AGRICULTURAL PROBLEMS OVERRUN TECHNICAL BOUNDARIES

As an industry, agriculture is bristling with economically important problems of production, processing, utilization, and marketing of plant and animal commodities and their by-products for which no one subject-matter department alone has the answer and in which agricultural engineers have an interest. For example, available knowledge on the use of alfalfa as a feed has focused attention on the importance not only of maintaining but also of building up its carotene content. At first thought these would appear to be problems for the plant breeder and agronomist, together with the animal nutrition expert. But alfalfa is rarely used primarily as a pasture crop, so that harvesting and processing for feed come into the picture here. Processing may take the form of ensiling or of curing for hay. The most favorable results from breeding and agronomic research as regards carotene content may become nullified by unsuitable harvesting procedures, improper ensiling, or unfavorable environment in either natural or artificial curing. The building up and maintaining of the carotene content of alfalfa thus becomes a problem for study in which, from beginning to end, sound engineering thinking must cooperate constructively with the other essential scientific approaches. It is not enough for agricultural engineers to cut off a segment of the problem for independent study, such as the development of cutting, windrowing, crushing, and loading machinery, the design of silos, or the development of artificial curing equipment. The purpose and direction of such work must be determined by the biological aspects of the problem, which are the functions of other subject-matter agencies.

In fact, the agricultural engineers in one experiment station predicated their entire procedure in connection with studies of natural field curing of hay under highly humid conditions on the findings of animal nutritionists, forage-crop specialists, and plant physiologists. The ultimate success of their research in this field was attributed by them to their good judgment in cooperating to the fullest extent with others interested in the problem and in concerning themselves from the beginning with the problem as a whole rather than merely with the segment which might be labeled "agricultural engineering".

By way of summary, it is believed that engineers wishing to participate in agricultural research should first recognize that, to best serve the industry, such work must be concentrated on a group of problems carefully selected by competent centralized authority to meet the most important practical field needs and with due regard to the limitations of available facilities. The research should be so organized and conducted under centralized direction and control as to bring all the essential sciences, including agricultural engineering, to bear on the problems under study in such a manner as to permit each to function and contribute its utmost to the final solution. In order to control the forces and utilize the materials of nature most effectively in solving these problems, agricultural engineers should understand them thoroughly and participate in planning the attack on them from the beginning. Since engineers rarely have the complete answer to agricultural problems, only occasionally will they be the sole leaders in *(Continued on page 397)*

Report of a Chick Brooder Study

By Lee C. Prickett
MEMBER A.S.A.E.

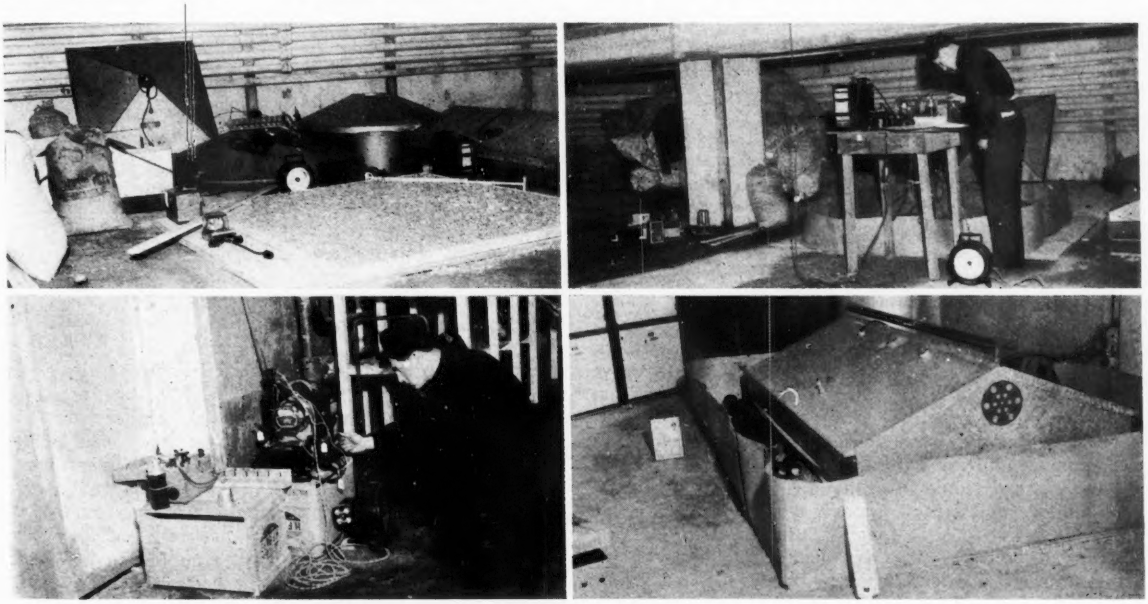
ELECTRIC hovers have been used to brood poultry for about a quarter of a century. During that time a considerable amount of research has been conducted relative to equipment characteristics, and if we judge by the satisfaction secured by the average user, there must have been a substantial improvement in effectiveness and design. However, there is still no one in position to outline the fundamental conditions essential to optimum brooding. For example what is the most suitable humidity range for the brooder house, also under the hover, and in what ways and to what degree does the relative humidity of the air affect the young chick and other types of young birds such as poults, ducks, or pheasants? What temperature, or range in temperature, is required for optimum brooding conditions for different types and ages of birds? What are the practical optimum space requirements per chick and to what extent and in what ways are they affected by climatic or weather conditions? How is the mortality, gain per pound of feed eaten; and rate, age, and completeness of feathering affected by brooding in an unheated room; and are these effects, if any, influenced by the outside temperature, and if so, to what extent?

There are quite obviously a number of fundamental questions relative to brooding which merit the attention of our best research talent. Until such time as at least some of the more important of these questions are answered, it is not likely that manufacturers will place on the market ideal brooding equipment in which are incorporated all, or even a major portion of the features necessary, if we are to consistently secure the best results. Likewise, with all of the pertinent facts available concerning the most desirable environment for brooding, it may be possible to design and build a brooder meeting these requirements which could then be produced under mass production conditions and sold in substantial quantities at a cash price a great deal below anything now within the realm of possibility.

It is quite obvious that there are still substantial difficulties in the way of bringing the benefits of electric brooding to every farm. Nevertheless, the REA felt that many new and old members of cooperatives would become users of electric brooders if they were given unbiased practical information concerning the design and use of equipment now on the market. This objective entails a considerable obligation, as those who are interested in electric brooders should have available certain understandable requirements with which prospective equipment can be compared. Quite obviously such requirements might be modified or the standards raised as knowledge of the art grows. The number who could profitably use such equipment increases in proportion to the expanding returns per dollar invested, be it due to more effective use or lower first costs, or both.

In order to bring the benefits of electric service to unserved rural communities, the REA makes self-liquidating loans, mainly to electric cooperatives owned and operated

Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. The author is agricultural engineer, Rural Electrification Administration, U. S. Department of Agriculture.



TESTING BROODER PERFORMANCE

(Upper left) Subfloor of three layers of ⅜-in plywood, covered with 2 in of medium fine planer shavings, for brooder test in room at 32 F. (Upper right) Checking temperatures beneath the hover with a potentiometer and thermocouples. (Lower left) Reading instruments outside of a locker room with temperatures below zero, in which brooder performance is being checked. (Lower right) Brooder in operation in room temperatures ranging from –4 to –7 F, with barricade around brooder, recording hygrothermograph, and thermocouple connections to potentiometer outside of room

by farmers, which must be paid back in the course of 25 years. The utilization division of the REA makes every effort to acquaint cooperatives with the income-increasing uses of electricity, as abundant use of electricity by cooperative members is essential to the success of these REA-financed cooperatives. The first comprehensive national program selected has, as an objective, the extension of the benefits of electric brooding to as many cooperative members as possible, and was initiated experimentally in two project areas late in the fall of 1938. There was a surprising response to our efforts and the program was expanded by personal contacts into as many projects in seven states as available time permitted. As a result of this experience it was felt that regardless of the difficulties involved, we must prepare a set of brooder specifications and provide some method of financing at reasonable rates. With this encouragement, programs relating to other income-increasing uses were planned along similar lines and are being prepared and launched as rapidly as available personnel permits.

SHORTAGE OF DATA ON BROODER REQUIREMENTS

In the actual preparation of the specifications for hover type brooders we sought information, advice and suggestions from the agricultural colleges and experiment stations, various government agencies (including the Bureau of Standards, Poultry Research Center, and rural electrification research section of the Bureau of Agricultural Chemistry and Engineering), various brooder manufacturers, the Underwriter's Laboratories, and various members of the American Society of Agricultural Engineers. We did not receive much encouragement, the general feeling being that such specifications would be a big help, but that the present stage of the art made their preparation out of the question.

However, we did secure a certain amount of data and with this, added to that obtained in our own tests (conducted under controlled operating conditions at the Poultry Research Center) as a basis, we prepared REA's minimum requirements for hover type brooders which include the fundamental general characteristics which seemed to be common to all good quality electric brooders. We might call these the least common denominators of hover type electric brooders.

It now seemed advisable to make comprehensive operating tests with typical brooders of different types (both with and without chicks) as a further check against the tentative specifications. Such tests were made in cold storage rooms at 32 F (degrees Fahrenheit) and at zero and lower, in refrigeration plants located at Harrisonburg and Timberville, Virginia.

As a result of these tests we liberalized our temperature requirements, since much to our surprise we found healthy and vigorous day-old chicks quiet and apparently comfortable all over the hover areas wherever actual temperatures, measured with thermocouples at a height of 2.5 in above the litter, were within a range of 80 to 110 F. There was no observable milling around. It is of course possible that with the chicks specifically marked we would have found them in due course shifting from one section to another. Not until we reached temperatures as low as 75 or as high as 125 F did we find areas definitely avoided by the chicks. In fact, it was possible to roughly outline certain temperature zones by noting where the numbers of chicks started thinning out and finally the point beyond which no chickens at all were found. These observations fit in with the experience of practical poultrymen who are doing a satisfactory brooding job in spite of temperature ranges beyond those commonly thought permissible.

We also modified our procedure for making the ventilation test, as we found a somewhat simpler procedure sufficiently accurate for our purposes and less difficult to make. We found, as expected, that from a comparative standpoint the data obtained on moisture removal enables us to predict the likelihood of a brooder giving satisfaction within the demands of the average user as to keeping the litter dry. Certain brooders, even when properly operated, have failed to keep the litter dry as the chicks got older, particularly when the weather was damp.

The requirements only relate to hover type brooders with areas of 1000 sq in or more beneath the canopy, and in general include (1) thermostatic heat control provided by units of minimum sensitivity and durability, (2) methods of adjusting curtain height above floor (head room considered), (3) pilot light, (4) attraction light, (5) provision for convenient inspection of chicks being brooded (without disturbing chicks), (6) thermometer, and (7) curtain on outer edge of hover which meets certain standards. Also specified are (1) the weight and quality of canopy and structural metal, (2) assembly of possible wooden parts with full consideration of fire hazard, (3) use of wiring materials in accord with the requirements of the Underwriter's Laboratories, (4) heating elements meeting certain demands as to chemical composition and operating temperatures, (5) protection of insulation against picking and mechanical damage, and (6) where fans are used they must be totally enclosed and permissible temperature rise and minimum frequency of lubrication are given. The operating requirements and data are intended to serve mainly as a guide in making comparisons of operating efficiencies, and the rather wide latitude allowed under the specified operating conditions include maximum total time the heating unit is on, weighted operating temperatures, and maximum temperature variation beneath the hover canopy.

INCREASES IN USE OF BROODERS

At this point it might be of interest to call attention to the effectiveness of the brooder programs fostered by REA cooperatives, as many had felt that an educational program (based on unbiased information) plus group purchasing, or other effective methods of obtaining good equipment at favorable prices, would not secure the desired results unless accompanied by an aggressive high pressure sales campaign. Last year an average of 21 brooders were added on each project where no personal assistance was given, whereas 62 brooders were added on those projects given assistance in setting up a program along the lines mentioned. We have no way of knowing what portion, if any, of the 21 brooders were added as a result of sending brooding information to the projects. This year our information is incomplete, but seems to indicate an increase of 10 per cent over last year. We feel that a fair portion of the response to this year's brooder program was due to much more definite information, supplied by REA specifications and the accompanying material, mailed to projects. In connection with this there is an evaluation schedule by means of which the total brooding cost per chick can be determined for each brooder by considering the guaranteed operating data required of manufacturers whose equipment is to be eligible for REA financing.

As more pertinent information is secured, the benefits of electric brooding should be proportionately extended, as it means better and more effective brooders and should in due course reduce the first cost of equipment. However, the equipment studies so commonly favored, while very helpful, will not necessarily solve the fundamental problems of brooding, at least not as quickly as desired. Nevertheless, with more or less formal investigations completed or under way in 26 states, the dark frontiers, with their illusionary twilight zone of theory and quasi-knowledge of equipment and operating practice, must inevitably recede.

How Much Should Farm Buildings Cost?

By H. B. White
FELLOW A.S.A.E.

IN primitive or self-sufficient agriculture simple structures usually prevail. Logs, sod, and adobe construction are commonly used, each in the locality where it is most easily secured. With the development of industry and factory methods, along with transportation, the rural home tends to change to a small factory producing raw food for those employed in industries. Sanitation, quality, and efficiency are necessary if sales are to be made in competition with other groups of producers. In some cases fertile soil is abundant in regions where the rigor of the climate makes shelter for farm animals a necessity.

It is well recognized that through competition agriculture produces raw material for food and clothing at a low cost. Unlike urban industry, the farm units are small and the overhead or management not well paid. Where the operator is not well established, he carries on his business with little capital invested in his plant or structures. To survive, he works hard with poor equipment and inconvenient and insufficient shelter, and often overcomes his handicap by long hours of low-paid effort. Usually his start in farming is made by renting land with buildings. With few exceptions, the renting system is the slow, hard way to start up the agricultural ladder. Usually it is the sure way. As the man gains in knowledge and experience he accumulates property, and after about thirty years he may be a well-to-do farm owner.

Usually he wishes to borrow money, develop his business rapidly, and reach his goal quickly. For this man, his structures will represent his judgment of what he will be able to pay for in the near future, without risking the loss of his land by inability to meet his payments. He may frequently say that if he only had some money he could make a lot more money. In fact, if he feels sure of his ability, he may succeed much more rapidly by borrowing capital on reasonable terms to enlarge or increase his business.

TIME SPREAD OF INVESTMENT IN FARM BUILDINGS

It has often been stated that when a farmer makes money, he will put some into his building improvements. This comes from people who have lived close to agriculture and who know from first-hand information that on the average farm, the investment in buildings is spread over a period of many years, often climaxed with a large modern house just as the elderly farmer and his wife should retire and let younger shoulders carry on the responsibilities of the complex, fully developed farm.

Carefully made studies have shown that approximately 25 per cent of the average person's income may be spent for shelter for the family. For the farm operator and his family, this should be 25 per cent of total income, including that from garden, bees, orchard, poultry, etc. This is for the house only. But it is evident to anyone who travels in the United States that thousands of farm families have annual incomes so low as to barely supply food only, and with little left for clothing or shelter.

When a farmer organizes his farm to raise certain crops and other products, he cannot tell what the returns will be over a period of years; hence, he is wise not to build extravagantly. If his capital is borrowed, the interest on the investment and the loan may be too much of a burden, and he will be unable to make a living for his family and repay the loan with the usual rate of interest. If the farmer is out of debt, needs buildings, and can pay for them as he builds, he need not be so careful that he make the customary 5 per cent interest that is so standard in the bookkeeping of farm management. He may be able to secure only 3 per cent interest if he invests in government bonds money he has on hand.

In the states along our northern border, comfortable buildings are expensive. Were it not for the fact that, for over fifty years, the raising of dairy animals, hogs, sheep, and poultry has been carried on by the most successful farmers with increasingly better shelter, it would seem that there might be some mistake in the farm management that requires such elaborate structures.

Much has been written about the subsistence farmers, some of whom settle in territory where they are unable to pay for roads and schools, and who have had to be moved by the government to more suitable farms. In this discussion the better built-up farms will be considered, as well as the average for certain sections where diversified farming is carried on with shelter as one of the necessities for success in the farm business.

COSTS OF SPECIFIC BUILDINGS

In the Midwest, barns for dairy cows are generally uniform in plan. A barn about 34 ft wide for two rows of cows costs from \$50 to \$70 per lineal foot. This makes an investment for shelter of \$85 to \$125 per cow. The annual charge for this shelter is commonly estimated as 10 to 11 per cent of the investment. This includes paint, 1 per cent; repairs, 1 per cent; insurance, taxes, and depreciation, 3 per cent; and interest on the investment, 5 per cent, —and amounts to \$8.50 to \$12.50 per year.

The Nebraska college of agriculture[1] has made a careful study and found that \$9.39 is the annual cost of shelter for a dairy cow, on a basis of 5 per cent of investment for depreciation, 5 per cent for interest, and 1 per cent for taxes and insurance. On this basis the maximum allowable structure investment per cow would be \$85.36. It might be raised to \$100, or even \$125 as a top limit. It will be appreciated that high-producing cows are the only ones that can pay for shelter of this quality.

Other animal shelters are similar in essentials to dairy barns. Hog barns may be built for \$20 per lineal foot of length when 22 ft wide. This makes the cost about \$80 for an 8-ft pen. If a sow is to pay 10 per cent annual cost for this space and keep her owner out of the red, she will be required to raise two litters per year. Poultry requires, for the farm flock, a 16-ft building costing about \$15 per foot of length and housing about five fowls, or approximately \$3.00 investment per fowl, with 30 cents annual cost for shelter.

A machine shed 18 ft wide costs about \$10 per foot of length. A building 64 ft long will shelter most of the implements on a quarter-section farm. Such a building costing

---

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 17, 1940. The author is professor in charge of farm buildings work, division of agricultural engineering, University of Minnesota.

---

[1]Yung, F. D. Investment per cow for housing. Agr. Engr. 21:2:50 (February 1940).

$640 represents an annual cost of about $64. Farm machinery depreciates about 8 per cent each year. On a farm with $3200 invested in farm machinery, the average annual depreciation is $256. If this depreciation can be cut only one-fourth ($64) by shelter, there would be an advantage in having a $64 annual cost for the shed, in which repairs could be made and the machines kept from rust and decay. In this connection it should be remembered that the more complicated the machines and implements, the more necessary that they be protected from damage from stock and weather.

The driveway one-story crib or granary costs about $15 per foot of length and shelters 45 bu of ear corn or 90 bu of small grain. This is an annual cost of 3⅓ cents per bushel of ear corn and 1⅔ cents for grain.

A building, if highly specialized, usually will not remain useful for a long period but becomes obsolete. Hence its depreciation is more rapid and the annual cost higher than in a structure that can be easily remodeled or used for other purposes as changes occur.

It is not difficult to determine the annual cost of buildings just as the cost of using an automobile or watch may be computed from records. It is the rather common challenge that the farmer spends too much for shelter that is back of this discussion. Of course, like other problems of a similar nature, there is such a range of cases that in a discussion the two sides are usually too far apart to reach any constructive conclusion.

PROGRESSIVE BUILDING DEVELOPMENT ON ONE FARM

Students frequently state they have been told that machine sheds or other buildings are not economical. Recently in a bulletin[2], under the topic "buildings and fences", the following statement precedes a schedule of the improvements made: "When the present operator of this farm moved on in 1921, he found a modest set of buildings, poor fences, and a debt large enough to rule out any but the most careful building program." Besides numerous improvements such as tiling and plantings, the owner has made the following improvements on his farm: 1923, fencing program began; 1924, water-pressure system (house, barn, and hog barn); 1926, concrete floor in barn, milking machine, and farm electric plant; 1927, hog barn and hen house remodeled and a concrete feeding floor installed; 1929, a combined corn crib and machine shed built; 1930, remodeled granary and built lean-to hen house; 1931, extended masonry silos from 35 to 50 ft; 1933, bathroom was added to house; 1934, hen house from old hog barn; 1936, new barn 32x82 ft and a milk house were built, also five portable hog cots, 10 brooder houses, and 16 range shelters for chicks and turkeys; 1939, new house 26x34 ft with annex.

It has been interesting to watch this set of buildings develop. Not only did this farmer and his wife attend short courses, but they brought their builder to the farm structures conference at the agricultural college before building the barn and house.

The importance of good buildings is shown by William Boss (Charter, A.S.A.E.)[3] in the following statement: "It is false economy to build poorly planned or cheaply constructed buildings as they cause a serious financial loss through high depreciation, and the additional labor involved in using buildings not properly planned or located. This statement is well proven by a recent study made by the division of agricultural engineering at the University of Minnesota on forty representative farms to determine the farm operator's labor earnings. The data reveals that the twenty farms having the best buildings have returned to their owners the largest earnings for the labor expended. This is proof that good buildings do pay. They not only pay for themselves, but they also enable the operator to secure a larger return for his labor, in addition to the pleasure and satisfaction he enjoys while doing his work, an important point which is often overlooked. A good operator will work better and more efficiently with good buildings than with poor ones. If the buildings are poor, he usually makes them better or gets another farm to operate."

RELATION OF BUILDINGS TO OPERATING EFFICIENCY

The justification for good buildings is further indicated by Dr. Andrew Boss[4] in the following statement: "A barn costing $4000, with an annual cost of $400, providing shelter for 40 cows, might be a better barn than one costing $2000, but it would not add to the net income unless the labor of doing chores was reduced by greater convenience. Good structures often help in attracting customers for stock, seed, grain, or other products. The satisfaction of owning good buildings and their influence in keeping young folks on the farm or in enabling one to keep hired help should also be considered." This statement from the farm management field is a recognition that buildings may become a business asset, either by saving labor or an increase in gross returns, or both.

Producing better living conditions for people and livestock is being generally accepted as one of the best uses of employment, as power relieves the worker of drudgery. In the June 1940 issue of Electricity on the Farm, I. P. Blauser shows that under a certain dairy setup, $3.02 per month could be saved by using a milking machine. Farm papers now carry advertisements of successful motor-driven manure removers for dairy barns.

As in many college classes the instructor gives more time to the students in the lower half of the class, so in extension work more emphasis is given the problems that confront farmers with low labor earnings. Carried on with normal extension programs this shows a large number of problems in which low-cost shelters are needed if the farmer is to remain in farming, even on a low-income basis. In many cases, perhaps, these individuals should be in industry and the farming done by better farmers with modern machinery and buildings, at low unit cost and producing materials of higher quality than at present. An example of an influence in this direction is the requirement that every farmer furnishing milk for a local market have a milk house that can be kept clean enough to pass inspection.

The fact that the investment in buildings on a farm tends to be proportional to income is generally recognized, but the fact that the buildings may help to increase the income is not so well known. The good farmer must have ability, good cows, good hogs, or good sheep, and in addition he must have good, convenient buildings. With them he usually secures a better income from his animals.

Like industry, farming must keep down the cost of production. The individual farmer must face the challenge to secure comfortable shelter for his animals and storage for his crops and equipment at a low annual cost. When a proper cost has been determined for buildings or automobiles for certain conditions, will the figures remain dependable very long? Probably not. Only the underlying principles stay the same, and each group or each individual must do his own deciding of many details after being given all the help possible from studies of farm management experts and agricultural engineers.

[2]A well-planned farm business. Agricultural Extension Bulletin 155, University of Minnesota.

[3]Living in the power age. Agr. Engr. 14:9:238 (September 1933).

[4]Farm management. Lyons and Carnahan (New York).

The Rehabilitation of Drainage Systems

By Clark E. Jacoby
MEMBER A.S.A.E.

SURVEYS and investigations required for rehabilitation and maintenance of old drainage systems are no different fundamentally from those required for the construction of new systems. In the application of methods and the sequence and time of doing work in rehabilitation and maintenance, however, there is offered a new field for investigation and experimental demonstration. This is true because we have an opportunity to investigate the systems that have been in operation for several years, to ascertain the causes of deterioration and to recommend plans designed to eliminate or at least minimize those causes.

During the years from about 1905 to 1922, we passed through a period marked with great activity in the construction of drainage ditches, floodways, and levees. Most of them were financed by organized drainage districts and were designed primarily for the drainage and protection of lands for agricultural purposes. In many cases, early pioneers in drainage found it necessary to adjust their design to the financial condition of the district. As a result, plans were sometimes inconsistent with the best hydraulic design. A review of a number of early designs indicates that financial limitations resulted in many inadequate drainage systems. Little thought was given during those years to the problems of future maintenance. In some instances where the plans did include works designed to reduce cost of maintenance, they proved to be inadequate and of little or no value. In rehabilitation work, however, it is possible and highly important to correct or at least improve upon some of the earlier designs.

Within the past ten years, the problem of proper maintenance of drainage systems serving lands of high agricultural value has attracted considerable attention. In 1935, 46 CCC drainage camps were established in the United States to assist and cooperate with local drainage enterprises in the maintenance and rehabilitation of public drainage systems. No work has been done by camps to rehabilitate private drainage systems, systems located in districts embracing lands of submarginal character, or to construct new ditches or systems.

The technical staff having charge of the government work in connection with the drainage camps was supervised by the drainage division of the U. S. Bureau of Agricultural Engineering until July 1, when the camps were transferred to the U. S. Soil Conservation Service.

In the areas where the drainage camps have been operating, the interest manifested by local district officials and landowners has more than met expectations. This interest has been expressed by hearty cooperation in raising funds for rehabilitation work. But what is more encouraging and will tend to insure more lasting benefits is the attention given to provisions for better and continued maintenance practices.

During the past 4½ years, opportunity has been afforded to those connected with this work to study drainage maintenance problems and to introduce to some extent experimental demonstrations designed to reduce maintenance costs.

DETERIORATION OF DRAINAGE SYSTEMS

The causes of deterioration and methods of prevention are covered for the most part in the more recent treatises and publications on drainage, to which this paper may perhaps add one or two suggestions.

Since the subject of proper land and water use has commanded the attention of technicians and laymen in recent years, it has been found that certain practices applicable to ditch maintenance are worthy of consideration and adoption. For example, ditch maintenance will be aided by reduction of runoff and soil losses from the steeper slopes in the watershed, and by maintenance of grass on ditch slopes, berms, and at least that portion of the spoil bank which slopes toward the ditch. Where practicable, the grass areas along the ditches may be pastured, but, in any event, the areas may be mowed, assuming that proper slopes have been provided.

The effectiveness of grass flume structures in preventing erosion at overfalls where outlets of open field drains discharge into a main ditch, has been demonstrated.

In a section of this country where vegetative and aquatic growth in and along ditches is overabundant, several miles of ditches have been kept free of these growths for a period of over 25 years by the shade of trees along both sides of the ditches.

Surveys for the rehabilitation of drainage systems should cover investigations of all the causes that have contributed to the inadequacy of the system under consideration. In general, these causes may be attributed to two sources: (1) errors or omissions in original design and construction, and (2) lack of proper maintenance. Most of the errors of original design, however, can be corrected and proper recommendations made for better maintenance practices if all the available background data are studied and analyzed. In some cases it will be necessary to extend surveys and investigations to secure sufficient data with which to check the adequacy of original design. It might be well to mention here that additional information is still needed concerning runoff from the smaller drainage areas, both from

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 7, 1939. The author is drainage engineer, Soil Conservation Service, U. S. Department of Agriculture.

Some drainage systems have been poorly designed, and many have not been properly maintained. The rehabilitation of a drainage system which is not functioning requires a complete engineering resurvey of requirements and physical factors involved in meeting them

hill land and flat bottom areas. This data should be supplied through further research.

The first section of the following outline covers required data which are generally applicable to surveys and investigations of all types of improvements in drainage systems; the second section of the outline covers more specific data for each type:

I. GENERAL REQUIREMENTS

1 Determine drainage area and locate all water courses affecting that area. Determine elevations or slopes of water courses and surrounding terrain, soil types, and cover. Topographic maps of proper contour interval, showing sufficient detail of elevation and slope, are desirable if they can be obtained.

2 Determine level datum and establish bench marks. If sea level datum cannot be used, a close approximate equation to sea level should be obtained.

3 Borings should be taken at sufficient depths to indicate the character and types of soil. Results of such bore tests should be used in establishing grade line of ditches, depth, and design of structures for obtaining materials suitable for levee construction and for similar purposes.

4 All physical characteristics of the drainage area should be located, and such elevations as are required for design, specifications, estimates, and construction should be determined.

5 Information should be secured regarding all high-water marks, their location, elevation, date, and frequency.

6 Determine soil types and classifications, preferably as referenced to soil survey maps and reports.

7 Determine land use, particularly along line of proposed work. Three classifications will normally suffice, namely, (a) woodland or timber, (b) permanent meadow or pasture, and (c) crop land indicating rotation, for example, corn 2 years, wheat 2 years, legumes 2 years.

8 Determine widths and field location of legal rights of way along line of improvements.

9 List and locate ownership of lands, particularly along line of work where additional rights of way will be required.

10 Obtain information in regard to dates when improvements were originally constructed and history of reconstruction and maintenance work that has been performed to date.

II. ADDITIONAL REQUIREMENTS AS APPLICABLE TO DIFFERENT TYPES OF IMPROVEMENTS IN DRAINAGE SYSTEMS

1 *Ditches.* The following information should be secured along present ditches where rehabilitation is proposed: (a) elevation of natural surface of ground along ditch; (b) location and elevation of any adjacent low lands which are poorly drained, checking at frequent intervals areas within 1000 ft of the ditch; (c) bottom width of ditch; (d) elevation of waste or spoil banks on both sides of ditch; (e) location, elevation, dates, and frequency of high-water marks; (f) location and elevation of roads, lateral and road ditches, open field drains, tile outlets, adjacent tile lines, head walls, pipe outlets, pipe lines, dams, railroads, telegraph, telephone, power lines, and other similar utilities; (g) location, floor elevation, and clearance of bridges and culverts; (h) elevations and locations of other physical characteristics along or adjacent to line of work, that might affect proper planning or execution of work; (i) location of fences, timber culture, section, township, range, state and county lines, and towns or trading centers.

Cross sections and measurements should be taken at all necessary points. For example, those necessary to secure actual and accurate varying physical characteristics, where there are changes in design, and where necessary to secure area measurements that will give required data to accurately estimate the cubic yards of excavation. Cross sections and measurements also should be taken of bridge and culvert openings, lateral ditches and field drains, tile, pipe, head walls, and similar structures which are located along or adjacent to the line of work.

2 *Levees and Floodways.* The data required for the rehabilitation of levees and floodways are the same as those for ditches, except that such elevations and cross sections will be taken as are applicable to levees and floodways. It is important that natural ground elevations be secured. In most cases, floodway elevations are not the same as natural ground elevations outside the floodway.

3 *Sedimentation or Settling Basins.* Data should include location and elevations of basin area, levee elevations and cross-sections, elevation of land outside of basin, number of years basin has been in use, inlet and outlet ditch conditions, elevations and cross sections of same, and all data with reference to permanent and relief spillways.

4 *Tile Lines.* Data should include location, elevation, dimensions of tile line, connections if practicable to determine, sand traps, catch basins, and manholes. It also is necessary to know the condition of the present line and its outlet, and, of course, soil conditions and drainage area which are mentioned under general requirements.

5 *Spoil Bank Leveling.* Cross sections taken should correspond to requirements outlined under ditches. Where it is proposed to use spoil banks for levees to prevent overflows or for floodways, surveys are necessary to establish proper grade lines and cross sections of proposed floodway. Locations of physical characteristics along line of work, including all drainage inlets through spoil banks and elevations of same, should be secured.

6 *Clearing.* Areas to be cleared should be located and measured, establishing width to be cleared on either or both sides of a reference line or the center line of proposed work. In cases where the timber, brush, or vegetation which is to be cleared is not uniform in width, the overall widths required may be given in descriptions. Field notes, however, should give actual area to be cleared, which should be used in computing the work to be accomplished in accordance with chosen units of measurement.

7 *Structures.* Measurement and elevation of all present structures should be secured along the line of work. Where repairs to present structures or new structures are required, borings and cross sections should be taken at all sites. Where erosion-control structures are required at the outlet of open drains, elevations and cross sections of the ditch above the outlet should be secured. On all proposed bridge work, elevations should be obtained on the center line of the road and cross sections of the ditch and of the roadway at each end of the bridge. Additional elevations and cross sections of the roadway should be obtained as are needed for determining bridge-approach construction or reconstruction. High-water elevations, dates, and frequency should be secured at all structure sites. Obviously it is necessary to know the load which the bridge will be required to carry before it can be adequately designed.

It may be of interest to note some of the causes of partial failure and deterioration of existing drainage systems. Of course, all of these causes may not exist in any one particular system, but they represent a summarization of causes which have been brought to attention through making proper surveys and investigations. These causes are enumerated as follows: *(Continued on page 392)*

Agricultural Engineering Aspects of Castor Bean Production

By Harry Miller
MEMBER A.S.A.E.

PRODUCTION of castor beans is not new to American agriculture. Extensive production occurred from about 1880 to 1910 in southeastern Kansas and adjacent parts of Missouri and Oklahoma. Production to a lesser extent occurred in other parts of the United States mostly in the cotton belt. The industry did not survive due to the large amount of hand labor required in harvesting the seed.

The castor bean is not a true bean, nor a legume. Botanically it belongs to the euphorbia group of plants such as the rubber and tung oil trees. Cross pollination occurs readily and for that reason there are hundreds of different strains exhibiting a wide variety of characteristics varying from a low-growing shrub to a tree of considerable size. Agronomical work on the selection and development of varieties is limited, although several of the state agricultural experiment stations have in recent years taken up work along this line. In such work, consideration should be taken what use is to be made of the crop. Ordinarily we think of producing beans from which to extract the oil, which has many possibilities in industry. The cellulose from its stalk is of good quality and may also find extensive use in industry. Examination of the different types reveals that the best seed producers are among the low-growing strains, although there are many such strains that produce little seed. Whether varieties can be developed that will yield paying quantities of both cellulose and seed remains to be seen.

CULTURAL PRACTICES

In climates where frequent and severe frosts do not occur the plant is perennial. However, in localities subject to temperatures below 20 degrees Fahrenheit, the plant must be regarded as an annual. Planting should be done at about the time when cotton and corn are planted. Experience thus far, with low-growing, seed-producing varieties, indicates that a standard check-row corn planter fitted with proper plates is satisfactory. The spacing should be about 42 in within the row and the rows should be about 42 in apart. Every third row should be skipped to give the plants the necessary room and to facilitate harvesting. Where cellulose is the desired material, the seed should be planted 4 ft apart within the row and 4 ft between the rows. Check-row planters giving that spacing are available from some of the farm equipment manufacturers.

Cultivation may be done with standard row-crop cultivators. The plant is very drought resistant, but responds well to abundant moisture. On early varieties seed production begins about 120 days after planting. The seed occurs in clusters made up of capsules each containing three seeds. Clusters occur on the same plant at all stages of development. As the earlier clusters ripen, new blossoms set on and advance toward maturity. This process continues until frost kills the plant. On most varieties the capsules burst and eject the seed as soon as they mature. With such varieties it is necessary to pick the clusters as they ripen, which may be twice per week during the season of maximum production. This is done by hand. Obviously such varieties cannot be grown commercially in this country. Before any variety can be considered, it must yield well; the seed must have a high oil content; the seed clusters must be large, and it must be shatter resistant to the extent that it will be possible to leave the seed on the plant and harvest all of it at one time after frost.

In 1937 I set out to find a variety that approached these requirements. I found four that appeared to be better than the average. These had been grown locally for ornamental purposes in the gardens of residents in Atchison, Kansas. The people who had the varieties that I considered good, made a practice of gathering their seed for next year's planting in the late fall or early spring. In this way they always obtained seed from the most shatter-resistant plants. This practice in all cases had been followed for thirty years or longer. One of these strains has since that time proved to be superior in yield, oil content of beans, and size of seed clusters. When seed clusters average about 8 oz of beans, it is possible for one man to pick 50 to 60 bu of threshed beans in a normal working day. The cost of this operation in that case is comparable to picking corn by hand. A machine for doing this operation is much desired and its development is a job for agricultural engineers. The threshing is probably best done by passing the beans between two rubber-covered rollers, one running about 50 per cent faster than the other. These rollers should be spaced so that they cannot come any closer together than the thickness of a seed, because it is absolutely essential that the seed be not damaged, in order to obtain a high grade of oil. Separation of the seed from the chaff and stems may be done in the usual way.

Good varieties of castor beans analyze approximately as follows: oil, 50 per cent; shells 23 per cent; and pumice 27 per cent.

The pumice contains 73 per cent protein, but it also contains a poison that renders it unsuitable for cattle feed. It is an excellent fertilizer, and where ground insects are troublesome it serves the dual purpose of destroying the insects and fertilizing the soil. The shells have no value as far as is known. Processes have been developed for rendering the oil suitable for high-grade paints and varnishes. We may, I believe, look forward to a tremendous industrial market for this oil. The oil represents no soil fertility and is the type of material that should be sold into industry. All the soil fertility is contained in the pumice, which should be kept on the farm where it grew.

PROCESSING FOR OIL AND FIBER

Equipment for expelling the oil on the farm should be of interest to agricultural engineers. The process is simple. It is only necessary to dry the seed to 3 per cent moisture or less, crush, and pass through an expeller and filter. The power from a small tractor is adequate to operate such equipment, which could also be used on other oil-bearing seeds such as flax, soybeans, sesame, and cotton seed. The

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 18, 1940. The author is a consulting agricultural engineer and chemist.

investment need not exceed that of other pieces of equipment that the farmer buys. It would certainly look absurd to market wheat in the bundle, and it appears just as uneconomical to sell oil-bearing seeds to the market and have the pumice come back to the farm either as a feed supplement or fertilizer.

A bushel of castor beans weighs 46 lb. One variety selected at Atchison, Kansas, yielded 57 bu per acre at Wichita Falls, Tex., 34 bu per acre at Winthrop, Mo., and 21 bu at Columbia, Mo. Obviously localities with the longer growing seasons can produce better yields, because seed formation goes on until frost kills the plant. The variety that produced these yields of beans yielded about one ton of cellulose per acre. This probably is not sufficient to warrant a cellulose industry. Where seed is desired, the plants should be small to facilitate harvesting.

There are other strains of castor beans that produce little seed and the plant reaches a height of 30 ft in a single year's growth. In the deep South, where the plant is perennial, a cellulose industry can be justified. Plants two years old reach a height of 40 ft and a diameter of 8 to 10 in. Such varieties yield from 4 to 8 tons of cellulose per acre per year, or twice that amount in two year's growth. The cellulose is of excellent quality. I have some sheets of paper made on a project with which I was associated in a consulting capacity. In some applications this product excels. The plants in this project contained about 70 per cent moisture as they came from the field, and there was about a 50 per cent yield of cellulose from the dry matter. Thus, 100 lb of material must be handled for 15 lb of cellulose. These varieties, like others, can be satisfactorily planted and cultivated with existing machinery. There is a need for a machine to harvest these trees and transport them to the end of the field, where they might be semi-processed in portable equipment. In recovering the cellulose it is first necessary to reduce the stalks to chips. This is done by a machine similar to an ensilage cutter, except that the stalks are fed to the knives at an angle of 45 deg to the plane of travel of the knives. Behind the knives is a little moldboard similar in shape to that of a plow to reduce the slices to chips as they are chopped off. The chips are then cooked under pressure in a dilute sodium hydroxide solution which dissolves the non-cellulosic constituents of the dry matter.

In an investigation with which I was associated it was found that by pressing the material discharged from the cooker, practically all of the non-cellulosic constituents could be eliminated and 50 per cent of the moisture as the stalk is removed from the field. Thus for each 15 lb of cellulose, 50 lb of material needed to be transported in place of 100 lb. The material can thus be reduced to conveniently handled cubes both for transportation and final processing at a central mill. The semi-processing equipment consisted of a steam boiler, pressure cooker, chipper, and hydraulic press. All of the operations performed would be necessary in any case and the saving in transportation is the net gain. This may make the difference required to make such a new industry feasible, based on utilization of annually grown agricultural products.

The Rehabilitation of Drainage Systems

(Continued from page 390)

1 Bottom gradient of ditch may have been too low or too high. If it was too high, the cause may have been failure to construct ditch to original specifications, improper original design, or subsequent silting of ditch. Where the bottom gradient was too low, it was either the result of erosion or a fault in original design. Faulty design was usually an attempt to maintain grade lines below sand strata where such additional depth was not required for proper drainage, and which in turn caused sluffing banks.

2 Ditch or floodway sections may have been inadequate to provide required depth of flow and carrying capacity. This condition may have been due to error in original design or subsequent silting of ditches.

3 Common causes of ditch silting are traced to failure to provide and maintain proper outlets for tile, pipe entrances, open field drains, road ditches, and lateral ditches.

4 Improper locations and alignment are frequent causes of failure.

5 Silt carried in suspension from steeper slopes and deposited in ditch sections of less slope is often responsible for a change in grade and failure of the system.

6 Even in areas or sections where the general average slope of the ground is uniform, failure to provide uniform depth of flow and velocities by construction of levees across localized depressions will result in checking velocities and deposition of silt.

7 Erosion from top of spoil bank to ditch increases silt deposits.

8 Inadequate culvert and bridge openings prevent proper flow of water.

9 Growth of vegetation, including aquatics, in ditches retards water flow and causes siltation.

10 Improper land use along open field drains and ditch improvements causes sheet erosion and increases the amount of silt entering outlet ditches.

11 Improper land use on higher lands adjacent to and above drainage systems increases the amount of silt to be taken care of on the lower levels.

12 And last but not least, the lack of interest in maintenance on the part of some of the adjacent landowners and tenants was apparent in many instances by violations of the law which prohibits the placing of obstructions in public ditches and construction of fences across them in such a manner that would restrict or impede the free flow of the water.

The hydraulic gradient is the slope that must be used in calculations of discharge. This gradient may or may not be parallel with the bottom gradient and is dependent upon field conditions.

Information in regard to soils secured by making surveys and borings is highly important. This data sometimes discloses causes of failure of structures, assists in selecting proper gradient of ditches, and specifying proper side slopes to prevent repetition of sluffing banks, and in the future will assist in planning proper land use along ditches.

Perhaps one of our most common traits is that of doing nothing about a situation that demands attention until suddenly we realize that something should be done and then we demand action tomorrow. This is a commendable attitude and should not be discouraged. But when it comes to construction or rehabilitation of public improvements, we should try to make the public understand that it is more important to delay actual construction operations a few days or months until proper surveys and investigations can be made, causes of possible failure or deterioration determined, and proper plans prepared. Otherwise, by proceeding inadvisedly we may perhaps repeat some of the errors that were made formerly. Or we may overlook the opportunity for experimental demonstrations which will help decrease maintenance costs.

Wear in Sprayer Nozzle Disks

By C. N. Turner
MEMBER A.S.A.E.

QUALITY of field or orchard spraying can be no better than the nozzle equipment will permit. Authorities state that as much as 50 per cent of the materials used in spraying may be wasted by the use of large disk orifices or improperly designed nozzles. Many growers are changing the nozzle disks in their spray brooms every day to maintain sufficient driving range and a good mist-like spray. Others, however, change the nozzle disks only when the wear is sufficient to increase the rate of discharge beyond the capacity of the pumping equipment, and the pressure drops. When the pressure drops or the size of the disk opening increases, spray solution is applied to foliage in larger drops, causing considerable run-off and waste. With this inefficient application, the impact of these larger drops of liquid also causes foliage burn amounting to considerable damage.

In a study of the failure of parts of potato sprayers owned by 85 growers in Aroostook County (Maine), I found that the sprayer nozzle disks represented 64 per cent of the total number of parts which failed. These disks seem to be a small item, yet the growers apparently felt that replacing them increased the efficiency of the machine and helped to give better control of diseases and insects.

Spray nozzle disks have been tested and studied with reference to the amount of corrosion taking place, but more work needs to be done from the standpoint of the effect of the liquid on the metal of the disk, due to the cavitation or impinging attack of the liquid traveling through the disk opening at high velocity. I feel that insufficient consideration has been given to the cavitation effect, in addition to the chemical or normal corrosive effect. The actual quotations from several different authorities who have conducted carefully controlled research along this line will be included in this paper to bear out the above opinion.

J. M. Mousson (Pennsylvania Water and Power Co.) states that "restoration of normal pressure results in a collapse of the cavity, which sets up terrific impact forces which in turn are transmitted to the adjacent metal, causing serious damage by pitting and eventual loss of the metal." He also found that the higher the Brinell hardness, the less the loss of metal.

H. N. Boetcher (Consolidated Gas and Electric Light and Power Co., Baltimore, Md.) gives the following explanation of the action on the metal, and also tells what qualities the metal should have to withstand the attack: "Initial pitting is caused by crushing or breaking out of small pieces isolated from the remainder of the metal by fatigue cracks. In order to have high resistance against 'cavitation fatigue' the metal should have high corrosion resistance in the water in which it is to be used, and physical and metallurgical properties which result in high fatigue resistance. It should be homogeneous and free from inclusions."

This information would seem to be adequate upon which to base a further study of a similar effect as it might occur at the inner edge of the drill hole in the spray nozzle disk. The pressures in the spray nozzle will range from 400 to 600 psi (pounds per square inch) and the rate of discharge from 2 gpm (gallons per minute) for multiple-nozzle guns to 12 gpm for the single-nozzle guns. The newest spraying outfits have greater capacity and higher pressure than ever before, which will tend to give more disk trouble than in the past.

A complete study of all the factors involved in the nature and extent of wear in spray nozzle disks would require several years of research and experimentation. Some of the known factors affecting the wear of the disk orifice are as follows:

1 Type and concentration of insecticide and fungicide used in the spray mixture

2 Amount of foreign material, such as sand, in the spray water supply

3 Pressure applied to the mixture at the nozzle opening

4 Size of the disk orifice, or any function of the nozzle which changes the rate of discharge

5 Variations in the construction of the nozzle, especially the whirl plate

6 Composition of the metal used in the nozzle disk

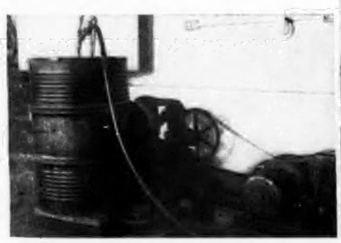
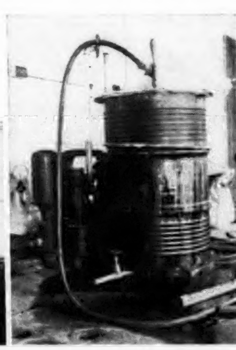
7 Heat-treatment, or the cold working applied to the metal used for the disk

8 Thickness of the nozzle disk

9 Whether the orifice is drilled or punched.

With the corrosion studies as a basis, an attempt is being made in this work to find out what metals best resist the abrasive

Presented before a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Farmingdale, L. I., N. Y., September 12, 1939. Based on a study made while the author was engaged in graduate study in agricultural engineering at Ohio State University. The author is extension agricultural engineer, Cornell University.

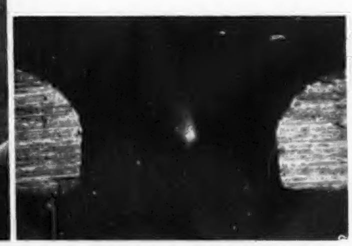


Fig. 1 (Extreme left) Testing equipment, showing motor, pump, steel drum supply and discharge tank, and location of four-nozzle broom at top of drum. Fig. 2 (Left center) Water running down the outside of the tank cools the recirculated spray mixture. Fig. 3 (Right center) Sprays at 460 psi from new disk (left) with 4/64-in hole and from disk (right) worn by 26 hr use with 8-8-50 Bordeaux mixture. Fig. 4 (Extreme right) Photomacrograph of worn disk cross-sectioned through its orifice at right angles to the direction of flow

TABLE 1. DATA FROM TESTS ON NOZZLE DISK WEAR

Disk No.	Manufacturer	Type of metal	Thickness, in	Rockwell	Gpm discharge Before test	After test	Per cent increase
			Test No. 1A 18 hr at 380 psi				
1	Hardie	?	.033	B-75	1.481	1.545	4.32
2	I.N. Co.	Z	.032	C-33	1.485	1.495	0.67
3	I.N. Co.	K	.035	C-27	1.477	1.507	2.03
4	I.N. Co.	IN	.032	C-27	1.481	1.509	1.89
			Test No. 1B 12 hr at 380 psi				
1	Hardie	?	.033		1.481	1.615	9.04
2	I.N. Co.	Z	.032		1.485	1.570	6.39
3	I.N. Co.	K	.035		1.477	1.580	6.98
4	I.N. Co.	IN	.032		1.481	1.560	6.15
			Test No. 2 26 hr at 380 psi				
5	Republic	18-8	.032	C-30	1.41	1.65	17.2
6	Republic	17-7	.032	C-35	1.41	1.64	16.3
7	U.S.S.	12	.033	B-93	1.46	1.63	11.6
8	I.N. Co.	IN	.033	C-27	1.54	1.77	14.9
			Test No. 3 26 hr at 460 psi				
9	I.N. Co.	K(H.T.)	.035	C-38	1.406	1.735	24.6
10	I.N. Co.	Z(H.T.)	.032	C-43	1.455	1.802	23.8
11	Allegheny	A 12	.030	B-74	1.463	1.813	23.9
12	Republic	17-7	.032	C-35	1.410	1.790	26.9

action of the liquid traveling through the orifice at high velocity. Tests have been conducted in such a way, however, that some conclusions might also be drawn from the changes made in the spray mixture and the pressure.

Disk material used in these tests was furnished by the manufacturers in sheet form. Disks were cut from the sheet with a circular saw and brought to the correct outside diameter by grinding. All orifices were centered and drilled with a 4/64-in twist drill.

Manufacturers furnished metal sheet strips for the tests as follows:

The International Nickel Co., Inc., New York, N. Y.
- Cold-rolled "K" monel strip, full hard temper.
  - Disk No. 2 was monel "K" in the "as-rolled" condition.
  - Disk No. 9 was monel "K" in the heat-treated condition.
- Cold-rolled "Z" nickel strip, full hard temper.
  - Disk No. 3 was "Z" nickel in the "as-rolled" condition.
  - Disk No. 10 was "Z" nickel in the heat-treated condition.
- Cold-rolled inconel strip, full hard temper.
  - Disk No. 4 in test No. 1 and No. 8 in test No. 2.

The Allegheny Ludlum Steel Corp., Brackenridge, Pa.
- Allegheny "12" stainless type No. 410 in cold-rolled condition.
  - Disk No. 11, used in test No. 3, was A 12.
- Allegheny metal 18-8-M in the cold-rolled condition. Time did not permit the use of this metal. It was selected as the only one to be omitted because it arrived after the 18-8 metal furnished by Republic Steel Corp., had been tested.

Republic Steel Corp., Cleveland, Ohio.
- Enduro 18-8-SMo type 316 No. 2, finished cold-rolled strip.
  - Disk No. 5 in test No. 2 was Enduro 18-8-SMo.
- Enduro 17-7 type 301-X No. 2, finished cold-rolled strip.
  - Disk No. 6 in test No. 2 and No. 12 in test No. 3 was Enduro 17-7.

Carnegie-Illinois Steel Corp., Cincinnati, Ohio.
- U.S.S. "12" type 410 No. 1 finish strip.
  - Disk No. 7 in test No. 2 was U.S.S. "12".

Hardie Manufacturing Co., Hudson, Mich.
- Standard disk supplied with spray pump and broom.
  - Disk No. 1 in test No. 1 was a standard Hardie disk.

For the first 18 hr of test No. 1 a mixture of 2 lb of wettable sulphur, 1 lb of arsenate of lead, and 2 lb of hydrated lime was mixed with 25 gal of water. The last 12 hr of test No. 1 was run with a Bordeaux mixture of 2 lb of copper sulphate, 2 lb of hydrated lime, and 25 gal of water. The pressure at the nozzle was 380 psi throughout the first test. The disks were changed in the broom head progressively from one end to the other every 5 hr so that no disk would have an advantageous position in the broom. Disk Nos. 1, 2, 3, and 4 were used in this test.

Test No. 2 was run with a Bordeaux mixture of 4 lb of copper sulphate, 4 lb of hydrated lime and 25 gal of water. The pressure at the nozzle was 380 psi, the same as in test No. 1. Nozzle disk Nos. 5, 6, 7, and 8 were used in this test.

Test No. 3 was run with the same Bordeaux mixture as in test No. 2, but the pressure was stepped up to 460 psi. Disk Nos. 9, 10, 11, and 12 were used in this test.

The spray mixture was renewed at approximately 10-hr intervals. Materials were held in suspension by agitation from the overflow of the pump which discharged into the bottom of a steel drum supply tank.

Test No. 1 was run for 30 hr. Tests No. 2 and No. 3 were run for 26 hr each.

Table 1 shows the rate of discharge in gallons per minute for each disk, before and after each test. Per cent of increase in this rate seemed to be the best measure of the durability of these disks. To get the rate of discharge all nozzles in the broom head were closed, except the one in which the disk to be rated was placed. This nozzle disk was then allowed to discharge through a 90-deg "factory bend" pipe into a container for 2 min at 380 psi pressure. Five 2-min runs were weighed to the nearest 0.01 lb for each disk. Table 1 gives the average rate of discharge for the five runs.

Another method of measuring the relative amount of wear was to take macrophotographs of each disk after these tests. The disks were cross-sectioned just to one side of the orifice and then ground and polished to the center of the orifice. The photograph shows the disk orifice from the edge. It shows clearly that the wear occurs on the edge next to the whirl plate.

CONCLUSIONS

The wettable sulphur, arsenate of lead, and hydrated lime mixture caused little wear as shown in Table 1, Test No. 1 A. The Hardie disk showed more wear than the others. This was due in part to the chemical corrosion attack of the sulphur.

The Hardie disk showed severe chemical corrosion throughout tests Nos. 1 A and 1 B.

Single-strength Bordeaux mixture was responsible for most of the wear on disk Nos. 2, 3, and 4.

Double-strength Bordeaux used in test No. 2 caused considerable increase in the rate of wear, even though the test was 4 hr shorter.

Test No. 3 shows the effect of a higher pressure at the nozzle on the rate of wear. This increase in rate of wear occurred even with three resistant metals.

A check metal was used so that all tests could be compared. With the Republic 17-7 steel as a check for tests Nos. 2 and 3, U.S.S. "12" steel showed the greatest resistance to wear of any of the ten metals tested. U.S.S. "12" did show some signs of chemical corrosion, however.

Inconel proved to be the metal second most resistant to wear and showed no signs of chemical corrosion.

Heat-treated "Z" nickel and Allegany "12" proved to be the third and fourth most wear-resistant types of metal.

A 4/64-in drilled hole in material 0.032 in thick does not form a true orifice but makes a cylindrical hole. The inside edges of this hole showed the only signs of wear on the entire disk. This wear can (Continued on page 405)

Engineers in the Production of Essential Oils

By Dr. Paul J. Kolachov

GROWTH of plants for the production of essential oils has been confined strictly to foreign nations. These nations over a period of many years have developed the planting, cultivating, harvesting, and processing of aromatic plants until their industries not only supplied growing world demand by gradual expansion, but also vied with each other on the basis that their product was superior. Both place of growth and methods of processing supposedly had contributed to this so-called superiority of product. The industry, in fact, was an art.

With the application of scientific methods to agriculture, it has been learned that results obtained in any one place can be reproduced and ofttimes bettered by selecting proper locations and controlling growth conditions. This is true in the planting of peanuts, fruits, grain, trees, flowers, and certainly is true for other plants. Investigations conducted by the author on the growth of various aromatic plants have definitely indicated that better grades of oils are obtained under controlled conditions.

In this paper I will show where and how aromatic plants can be grown in the United States, and how they can be processed to supply the American market demand for essential oils. Six species will be discussed as examples, namely, coriander (*Coriandrum sativum*, L.), caraway (*Carum carvi*, L.), anise (*pimpinella anisum*, L.), fennel (*Foeniculum vulgare*, L.), angelica (*Angelica archangelica*, L.), and licorice (*Glycyrrhiza glabra*, L.)

Strangely enough there is no cultivation of these plants in the United States, although this country consumes a great amount of aromatic raw material, all of which is imported. That is why we wish to call your attention to the introduction of aromatic plant culture in the United States, and to indicate your role, as agricultural engineers, in the essential oil industry.

CULTURAL REQUIREMENTS OF AROMATIC PLANTS

Selection of a proper locality is important in starting a plantation for the growth of aromatic raw materials. However, the various aromatic plants require such different conditions for their growth that it is impossible to give any specific rules that would be applicable to all such plants. It may be said, in general, that the best location is flat country having small hills, since the mechanical processes of cultivation can be most easily handled on flat ground.

One of the first conditions for the cultivation of any aromatic botanical is a fertile soil. The soil must have a good physical structure, it must be easily penetrated by air, and it must have a sufficient amount of humus or organic material, so that it will be neither powdery nor caked on the surface. The best soils are black top soil, with sandy or light clay subsoils having a sufficient amount of humus. Soils containing over 50 per cent clay, all clay, or poor sandy material are less suitable. Usually a certain amount of lime (10 to 15 per cent) is considered desirable in soils where aromatic plants are grown. In order to obtain the necessary moisture, porosity of soil is important, since this type of earth holds the water for a long period of time, absorbs heat easily, and permits free passage of air to the roots, all of which are requisites for the normal growth of aromatic raw material.

The soil is prepared for planting by plowing, which must be deep enough to insure a fast growth of roots, and therefore of the plants themselves. Plowing can be done by ordinary implements.

Success in planting aromatic raw materials depends upon several factors, the following being the more important:

1 Thorough preparation of the soil at the proper time
2 Planting in the season established as most suitable for each type of aromatic plant
3 Thorough but not very deep planting of clean, grade A seeds or roots in a wet ground; the seeds must have shown high percentage of germination in the previous year's crop
4 Planting using well-developed technique (which will be explained later)
5 Good care of the planting after seeding.

PLANTING PRACTICES AND EQUIPMENT

Planting of aromatic crops is usually accomplished either in the spring or in the fall of the year, depending on the species. Early spring planting begins as soon as the ground thaws and is sufficiently dry so that particles of soil will not cling to the planting implements. In this season the seeds of those plants which do not suffer from temperatures below freezing, for example, caraway and anise, are sown.

Late spring planting continues until the end of April or the beginning of May, depending on the quality of soil. Crops adaptable to late spring planting are coriander and fennel, although on the whole, early spring planting gives better results.

Fall planting must begin early, around the middle of August or the beginning of September, or late, just before the frost begins. In the first instance, the sprouts of such crops as caraway and fennel will have time to develop and get firm before winter sets in. In the second case, practiced with coriander and fennel, the seeds are not given a chance to even begin sprouting or germinating before winter. However, late fall planting is rather dangerous, since early spring storms may be so violent that the whole crop, together with the porous black soil, could be blown away, whereas crops planted in early fall have enough time to establish themselves and grow strong enough to withstand storms.

An ordinary drill or seed planter can be used for the sowing of seeds, but for planting roots we suggest the use of a tomato planter which, with some experimentation, can be adjusted for the automatic planting of any root. It is important to have the rows of seed or roots absolutely straight, as on this depends a successful weeding and replowing. Almost all aromatic plants belong to the group which requires at least one additional shallow plowing after planting. In order to insure a uniform distribution of seeds, it is advisable to mix them with dry sand.

Because almost all aromatic plants have seeds of small size, they require a shallow planting, which is hard to effect in soft black soil. When such soil is used, it is advisable to press the earth down slightly with a land roller

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 18, 1940. The author is director of research, Joseph E. Seagram and Sons, Inc., Louisville, Ky.

TABLE 1.

	Coriander	Caraway	Anise	Fennel	Angelica	Licorice
Soils	1 Black soil 2 Sandy black 3 Rich limy Soils with swampy drainage are unsuitable	1 Black top soil with sub-sandy or sub-clay soil 2 Sandy 3 Swampy	1 Marllike and limy soils rich in humus 2 Black soil	1 Sandy black soil 2 Rich limy and wet 3 Sandy clays 4 Can thrive on limy stony soil	1 Black top soil with sub-sandy soil 2 Sandy soil 3 Swampy soil 4 Soil bordering rivers and lakes	1 Salt marshy type 2 Sandy black 3 Soil bordering rivers and lakes
Fertilizer requirements in pounds per acre (one year prior to planting)	Type: Humus and phosphorus in form of superphosphates Amount, lb: 250 to 350	Type: Potassium in form of potassium chloride Amount, lb: 90 to 130	Same as coriander	Same as caraway	Same as coriander	Type: Humus and nitrogen in form of ammonium sulphate Amount, lb: 150 10 250
Depth of plowing, in	5-8	7-8	7-8	7-8	7-10	12-18
Seed, in pounds per acre	10-13	10.5-13	10.5-12.5	7-9	8-11	8-10
Distance between rows, in (Seeds)	15-22.5	15-22.5	15-22.5	22.5-27.5	24-28	24-28
Distance between rows, in (Roots)					6-18	25
Seed planting depth, in	1.2-1.6	1.0-1.2	0.8-1.2	0.8-1.2	0.75-1.2	1.2-2.0
Root planting depth, in	—	—	—	—	1.5-2.4	1.5-2.4
Spacing between plants in rows, in	8-10	10-12	8-10	14-16	12-12	18-24
Vegetation period, days	52-60	50-154	13-140	150-160	150-175	150-170
Growth to maturity, years	1	2	1	1 small crop 2 regular	2	3-4
Harvesting period	fall	fall	fall	fall	seed—fall; root—spring or fall	root—spring, fall, or winter
Approximate yields, lb per acre	750-2200	900-1100	1200-2400	1000-1400	900-1300	900-3300 (roots)

just before seeding. An entire crop can be ruined from planting the seeds too deeply, especially if the seeds are very small.

Care after planting is mainly in weeding, replowing, and watering. Weeding is the most important of these three processes, as weeds are the worst enemies of aromatic crops. It is better to give the land one or two extra weedings than to take the chance of losing an entire crop. A field tiller or weeder can be used, the necessary adjustment being made for each plant.

In the process of cultivation, the land must be harrowed, but the furrows should not be made deeper than 1.5 to 2.5 in, especially in dry weather, since otherwise the soil will dry out.

Optimum harvesting time varies with the plant, since the degree of ripeness desired differs with the species. Ripeness depends not on the amount of herbage or flowers or seeds, but on the quantity and quality of essential oil contained at the various periods of growth and ripeness. Further, the amount of oil in the plant depends on the time of day during which harvesting is done. There can be considerable loss in yield of essential oil if the crop is collected at the wrong time of day. It is obvious, therefore, that each species must be studied thoroughly before harvesting time can be determined. Usually the best period of the day is just before the morning dew disappears. Combines adaptable to the handling of small seeds can be used for harvesting the seed crops.

After the crop is harvested, the seeds must be threshed, graded, and dried, or, in the case of roots, cleaned and dried. A special tool for cleaning licorice roots must be developed, since the present craftsman's method used in Europe is not satisfactory. This tool could be similar to a potato cleaner, except that the knives should be replaced by metal brushes.

Raw material having a moisture content higher than that indicated following must be submitted to drying as soon as possible, in order to prevent any alteration in its essential oils. For this purpose, a drying machine that can be moved from plantation to plantation should be employed. The temperature of drying the aromatic plants mentioned should be 86 F (degrees Fahrenheit). For licorice, a temperature as high as 104 F may be used. When dry, the maximum moisture content permissible in coriander, caraway, anise, fennel, and angelica seeds, is 12 per cent. Licorice root may have as high as 15 per cent; angelica root, 10 per cent.

Aromatic raw material that is ready for sale must be kept in dry, dark warehouses which have a low temperature and good ventilation. Low temperature and darkness help to avoid losses of essential oils through evaporation, and structural alteration of the perishable components contained in the plants. The author's investigations show that there were losses in essential oil content of materials stored under uncontrolled conditions, whereas the amount of essential oils in properly stored seeds and roots remained constant. For this reason, our company stores its aromatic raw material for gin production in a warehouse having an air-conditioning system with a constant humidity of 65 per cent, and a temperature of 48 F.

Aromatic materials can be used in the form of either seeds or roots, as condiments for food, or as ingredients in perfumes, medicines, liquors, etc. When crushed, extracted, and concentrated, they provide essential oils. In order to obtain the oil properly, crushing is necessary, as this opens the cavities inside the seeds and roots which contain the essential oils, thus allowing the oils to be separated from the plant proper.

The main practicable methods for the removal of essential oils are (1) atmospheric distillation of plants, either (a) water extraction, or (b) steam distillation, and (2) low temperature (vacuum) distillation. The most important difference between the two types of atmospheric distillation is in the use of water in the first case and dry steam in the second. The former has several inconveniences. In water extraction, steam is formed within a kettle containing water

and aromatic material. Heat is applied either by a double bottom or by a direct flame. In this process, part of the raw material may burn along the walls of the kettle, thus adding volatile products of decomposition to the distillate, or, in some instances, the essential oil itself, after being in contact with the hot walls of the kettle, may become decomposed.

DRY STEAM DISTILLATION FOR QUALITY OILS

The second and most widely accepted method is dry steam distillation, in which the dry raw material is placed on perforated partitions inside a kettle at even distances from each other. Steam is produced outside of the kettle in boilers, whence it is injected into the kettle from the bottom by means of perforated copper coils and travels through the partitions. Since the steam is evenly spread inside the kettle, the danger of localized overheating is avoided. The presence of several baffles or partitions also helps to overcome this difficulty.

The average charging capacity of a steam still is 4000 to 5000 lb of raw material, which furnishes from 40 to 150 lb of essential oil, according to the percentage of oil in the aromatic plant used. In many instances, different aromatic plants require different still capacities. For example, while 1.0 lb of mint requires a corresponding capacity of 1.0 gal in the still, 1.0 lb of coriander needs only 0.5 gal. The thickness with which the raw material is laid on the partitions varies also with the plant used and its unit size. The finer the particle and the softer the material, the thinner the layers on the partitions should be. The average capacity of a partition or plate is 75 to 100 lb per sq ft. The vapors of steam saturated with essential oils pass into an air cooler and then into a condenser where the two mixed liquids drain into a special decanting container, the oil and water being separated by difference in specific gravity.

The decanting container may be one of two types, depending on whether the oil is heavier or lighter than the water. The oils from the six plants discussed in this paper are lighter than water, and are removed from the top of the container. In this instance, it is very important to drain the water from the bottom of the container as rapidly as possible. Some of the water may be recycled to the boiler. The capacity of the average decanting container is approximately 2 to 2.5 gal. It is usually made of copper or glass and is hermetically closed to avoid loss of oil by evaporation.

There are numerous types of condensers, but the best for these oils are straight copper shell-and-tube types, because they are the easiest to clean. Cleanliness is vital in the essential oil industry.

The rate of distillation is very important, as a distillation that is too fast will not permit the steam to make a thorough extraction, while one that is too slow may lead to overheating of raw material and, in consequence, to alteration of its quality. It is necessary to establish the appropriate rate of distillation for each aromatic plant.

The water which forms the steam must be of the best quality. As condensation inside of the kettle is undesirable, the kettle walls should be insulated and covered with a resistant paint.

In the two types of distillation mentioned, the resultant essential oil must be rectified. The best method for rectification is a vacuum fractionate distillation of oil. Our company's research department developed a method of direct vacuum extraction of essential oils from raw material which gives a purer oil. Oil extracted in this fashion has a much milder aroma, due to the fact that (1) the temperature of distillation is considerably lower and therefore decomposition of materials is minimized, (2) decomposition of terpenes and of carbohydrates is eliminated, (3) the splitting of higher esters and alcohols is avoided, and (4) the most volatile parts of organic material are carried over in the distillate.

CONCLUSIONS

1 American farmers should start cultivating aromatic plants.

2 Small farms should increase the variety of their crops. Under the agricultural system of a single type crop on a whole farm, in good years there is overproduction, and in poor years entire loss of income due to crop failure.

3 By planting simultaneously a greater variety of crops, the farmer multiplies his chances of being protected against total crop failure.

4 Farms on which aromatic plants are grown should be run on a cooperative basis, so that the movable agricultural implements may be interchanged.

5 The U. S. Department of Agriculture should experiment with the entire field of aromatic plants in order to investigate the possibilities of their cultivation in this country.

BIBLIOGRAPHY

Gibbs, W. M. Spices and how to know them. Matthews-Northrup Works. Buffalo, New York. 1909.

Lestschuk, T. Y. Practical guide for the cultivation of aromatic plants. Food and Industry Publishing Company. Leningrad. 1936 (In Russian).

McNair, J. B. Spices and condiments. Field Museum of Natural History. Chicago, Illinois. 1930.

Naves, Y. R., and Mazuyer, C. Les parfums naturels. Gauthier-Villars. Paris. 1939.

Redgrove, H. S. Spices and condiments. Sir Isaac Pitman and Sons, Ltd. London. 1933.

Youngken, H. W. A textbook of pharmacognosy. P. Blakiston's Son and Company, Inc. Philadelphia. 1936.

ACKNOWLEDGMENTS: The author wishes to express his grateful appreciation to Miss Alexandra de Glazoff, who is in charge of the gin and botanical division of Seagram's research department, for collection of data; to Howard C. Orr for figures and photographs; and to Miss Jane Wald, research librarian, for preparation of the manuscript.

Why and How Agricultural Research Involves Agricultural Engineers

(Continued from page 384)

agricultural research. What can be labeled as strictly agricultural engineering is likely to be a technological segment of a far larger problem. As a probable consequence, engineers will frequently not be the dominant factors in agricultural research. However, it should be fully recognized that they are far from being on the defensive and that they can become indispensable factors if they are willing to forget their identity and prerogatives, and to concentrate their thinking and action on the larger objectives of agricultural research. This means that they must be always on the job, quick to recognize their place and part in research, and always ready and willing to make their contribution from the beginning and to the extent warranted by the problem in hand. Thus the most effective participation in agricultural research by engineers is that which begins at the planning stage and continues in cooperation with the other essential scientific approaches throughout the life of a research project, in the form of either advice or action, or both. Through such participation the most effective agricultural engineering workers are those "who best can work and best agree."

Advances in Sanitary Milk Production in California

By J. D. Long

THE requirement that milking barns and milk houses for the production of market milk and cream meet minimum sanitary standards is in keeping with the general trend of the public health program. All structures intended for the handling and processing of foods which are readily susceptible of contamination are required to meet certain structural standards.

It is generally agreed that the actual design or construction of the structure, or even its cleanliness, has a relatively small direct or immediate effect on the wholesomeness of the product. Rather, the major value of such requirements from the sanitary standpoint is largely psychological. They encourage the worker to protect the product from contamination by making it relatively easy for him to do so, and by establishing standards to influence his thinking on the importance of cleanliness. With favorable mental attitudes established, sanitary precautions and practices become more or less automatic.

The progress of code standardization in California probably parallels that of other states. In 1930 a confused situation existed. Dairy inspectors of the various municipal, county, and state public health services were not in agreement as to the interpretation of the existing state code, and local agencies were enacting individual ordinances. Dairymen marketing in two or more areas under different inspection offices were frequently held to confusing and even conflicting interpretations of the prevailing standards. Difficulties and penalties in a dairy construction program were frequent.

GETTING TOGETHER ON SANITARY REQUIREMENTS

In 1931 a committee representing the California Dairy Council, a trade promotion association, met with representatives of the state department of agriculture and of the University of California. Criticisms were offered on the series of dairy plans then available from the University, and suggestions offered on the development of new designs and structural features. Subsequently this advisory relationship to the two state agencies was assumed by a committee of the Association of Dairy and Milk Inspectors, California League of Municipalities, and an active cooperative relationship maintained over a period of five years.

One of the first basic steps was the publication in September 1933 of a University mimeograph, Agricultural Engineering Information Series No. 5—"Public Health Standards for the Construction of Milking Barns and Milk Houses." In this were set forth the then prevailing minimum standards deemed acceptable by the advisory committee. These were reached only after numerous meetings with groups representing all phases of the industry. The meetings and hearings which were held throughout the state on this matter were considered an important part in the program of more or less voluntary compliance with the standards which were being developed. These standards were then used as the basis for design of the farm building plans distributed by the University.

Due to opposition developed in one area from the enforcement of these standards by the inspection services, the 1937 state legislature authorized the development of a uniform state code and the distribution of approved plans at cost by the director of the state department of agriculture. After another state-wide series of public hearings the "standards" developed earlier were modified for adoption as Regulation 22, Dairy Service, State Department of Agriculture. The University plans were revised and were designated as the approved plans, with the distribution delegated to the University. Charges of 25 to 75 cents per set of working drawings, specifications, and material lists were established to defray costs of blueprinting, mimeographing, and mailing.

For the eight years, 1932 to 1939, a total of 4,429 milk house and milking barn plans were distributed by the University extension service, a few going outside the state. Of this number, about one-third were for milk houses and two-thirds for milking barns; most of the milking barn designs include attached milk houses. At weighted construction cost estimates of $500 for the milk houses and $1,450 for the milking barns, the above distribution represents a potential new building valuation exceeding $5,000,000. That these assumptions are not far from the actual construction influenced by the program is indicated by the list of approximately 3,000 new milking barns compiled by the state department of agriculture.

At times a readily understandable resentment has arisen among the producers who were being required to modify or amplify their facilities. Where the program has been carefully explained and sympathetically enforced, however, the producer attitude has, in the main, been satisfactory. The dairymen have recognized the code as a necessary public health measure, and one designed to encourage favorable consumer reaction and to strengthen market demand.

One interesting and significant feature of the program has been the desire of many dairymen to exceed the minimum standards written in the regulations and incorporated in the approved plans. This is often evidenced in the design of the dairy, in *(Continued on page 405)*

TABLE 1. DISTRIBUTION OF UNIVERSITY OF CALIFORNIA MILKING BARNS PLANS BY TYPES, 1932-39

No.	Plan	Number	Per cent
C-132	One-string milking barn and attached milk house	987	34
C-133[a]	Parallel-stall, walk-through barn and milk house	526	18
C-134	Two-string, face-in milking barn	773	26
C-135	Four-string milking barn	103	4
C-170	(C-190)[b] Two-string, face-out milking barn and attached milk house	519	18

[a]Plan C-133 has been in disrepute with dairy inspectors during recent years due to the tendency of some milkers to avoid washing in such stalls, and they have discouraged new construction of this type.

[b]Plan C-190, comparable to C-134, has been available only the past two years but is proving much the more popular.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 18, 1940. The author, at the time of preparing and presenting this paper, was assistant professor of agricultural engineering, University of California, and is now agricultural engineer, Douglas Fir Plywood Association.

The Role of Nickel in the Production of Farm Tools

By H. L. Geiger
MEMBER A.S.A.E.

IN THIS paper the fundamentals of the materials used, as well as typical applications, will be discussed. Since the scope of application falling under the heading of farm tools is large, a paper of this type can be little more than an outline. By the term "farm tool" is meant any unit, whether mechanized or hand operated, used in the production of agricultural crops.

There is no question in the minds of those who have handled a tractor, combine, mower, or hammer mill that the fundamental metal employed in their construction is either steel or iron or both. Many, however, are not familiar with the means employed to meet the exceptionally severe service to which some of these parts are subjected, and it is this phase which will be principally stressed in this paper.

Developments in design leading up to the present state of perfection in farm tools have necessitated equally rapid progress in the development of materials to meet present day demands. Those responsible for the selection of materials in recent years have found it necessary to employ alloys to improve the strength of their steels and irons to meet increasing physical property requirements. In this development, nickel as an alloying element has played an important role. Within recent years two to four million pounds have been used annually in alloy steels and irons employed in all types of farm tools.

PART I. STEEL

Steel is the basic material used in the construction of farm tools. It is specified by means of the S.A.E. numbering system, a standard used throughout the entire steel producing and consuming industry in this country. Briefly this system of numbering is as follows: Plain carbon steels have "1" for the first digit, the straight nickel steels "2", the nickel-chromium grades "3", and steels containing molybdenum "4", etc. In the straight nickel steels, the second number indicates the approximate nickel content and the same is true of the nickel-chromium steels. The second number of the molybdenum steels has no relation to the analysis, as, for example, 4600 grades refer to a steel with 1.75 per cent nickel, 0.20 per cent molybdenum content. The last two spaces permit insertion of the carbon content, as, for example, 3115 refers to a 1.25 per cent nickel, 0.65 per cent chromium steel with 0.15 per cent carbon content.

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. The author is metallurgical engineer, development and research division, International Nickel Co., Inc. Part II of this paper will appear in AGRICULTURAL ENGINEERING for November, 1940.

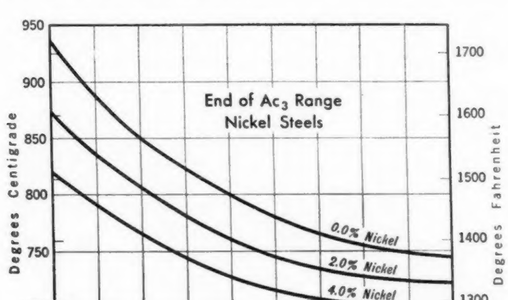


FIG. 1 EFFECT OF NICKEL ON CRITICAL HARDENING RANGE

A selected list of nickel steels generally used in the production of tractors and implements parts is shown in Table 1. Some of these, it will be noted, have carbon contents of 0.15 or 0.20 per cent, while other carbon contents range from 0.30 to 0.50 per cent. Steels with the lower carbon range are employed in parts which must of necessity be carburized to obtain maximum resistance to wear, while the 0.30 to 0.50 per cent carbon grades are direct hardening and are employed where higher strengths are desired, but where the optimum in wear resistance is not needed.

Carburizing Steels. The trend has been to employ carburizing steels for gears in tractors, mower transmissions, ensilage cutter drives, corn picker drives, and in any other unit where resistance to wear and shock are primary requisites. Alloy carburizing grades are used in place of the plain carbon steel, principally because of the greater degree of wear resistance imparted over the plain carbon carburized steel. In addition, the alloy provides greater resistance to crushing loads, particularly in tractor gears, improves resistance to pitting fatigue failures, and provides considerably more core strength than plain carbon steel. This last advantage of the alloy carburizing steel is of great importance in design as failures of plain carbon steel may sometimes be eliminated by substituting the stronger alloy steel without changing the design or enlarging the part in question.

Core strength of the plain carbon carburizing steel 1015 and the commonly used nickel-chromium steel 3115 are compared in Table 2. Values for SAE 4815, the 3½ per cent nickel-molybdenum carburizing steel, are also included.

TABLE 1. NICKEL STEELS COMMONLY USED IN FARM TOOL PRODUCTION

S. A. E. Spec.	Carbon	Manganese	Nickel	Chromium	Molybdenum
3115	0.10-0.20	0.30-0.60	1.00-1.50	0.45-0.75	....
3120	0.15-0.25	0.30-0.60	1.00-1.50	0.45-0.75	....
3140	0.35-0.45	0.60-0.90	1.00-1.50	0.45-0.75	....
X-3140	0.35-0.45	0.60-0.90	1.00-1.50	0.60-0.90	....
3145	0.40-0.50	0.60-0.90	1.00-1.50	0.45-0.75	....
3250	0.45-0.55	0.30-0.60	1.50-2.00	0.90-1.25	....
4615	0.10-0.20	0.40-0.70	1.65-2.00	....	0.20-0.30
4620	0.15-0.25	0.40-0.70	1.65-2.00	....	0.20-0.30
4320	0.15-0.20	0.40-0.70	1.65-2.00	0.30-0.60	0.20-0.30
4340	0.35-0.45	0.50-0.80	1.50-2.00	0.50-0.80	0.30-0.40
2315	0.10-0.20	0.30-0.60	3.25-3.75	....	....
2320	0.15-0.25	0.30-0.60	3.25-3.75	....	....
2330	0.25-0.35	0.50-0.80	3.25-3.75	....	....
2345	0.40-0.50	0.60-0.90	3.25-3.75	....	....
4820	0.15-0.25	0.40-0.60	3.25-3.75	....	0.20-0.30
2515	0.10-0.20	0.30-0.60	4.75-5.25	....	....

It will be noted that the tensile strength in the nickel-chromium grade is nearly double that of 1015, whereas the yield point is more than doubled. The presence of nickel raises the yield point in relation to the tensile strength, whether in the as-rolled condition or in the heat-treated condition. Another function is that of raising the quench hardness. From the above data ordinary 1015 quenched from 1625 F (degrees Fahrenheit) in oil has a core hardness of 180 Brinell, while 3115 quenched from 1475 F in the same quenching media develops a core hardness of 335 Brinell, and the more highly alloyed nickel-molybdenum steel, 4815, develops a core hardness of 375 Brinell with the single-quench treatment. It will be further noted that there is a lowering of the quench temperature with an increase in nickel content for the above steels. This function of nickel to lower the critical hardening range (Fig. 1) is advantageous from the standpoint of the heat-treating department, since a lower hardening temperature is less conducive to distortion and change in volume than in the case of steels where a high quench temperature is needed. Nickel also contributes to lower distortion by its function of alloying 100 per cent with the ferrite phase of the steel. The tendency towards distortion in hardening has been noted to increase with increasing amounts of active carbide forming alloys, particularly when in the complete absence of ferrite strengthening alloys. Nickel also has the definite characteristic of retarding grain growth in steels, at the same time acting as a refiner of the carbide structure, although not combining chemically with carbon.

TABLE 3. EFFECTS ON CORE STRENGTH OF THREE TYPES OF HEAT-TREATMENT USED IN CARBURIZING GRADE NICKEL STEELS FOR TRACTOR AND IMPLEMENT GEARS

	Core Properties							
S. A. E. Spec.	Type of heat-treatment after carburizing	Tensile strength lb. per sq. in.	Yield point lb. per sq. in.	Per cent elong. in 2 in.	Per cent Red. in area	Hardness Brinell	Izod Impact ft.-lb.	Case hardness Rockwell C
3115, 3120	A	125,000	85,000	25	55	255	55	62–63
3115, 3120	B	155,000	125,000	13	43	335	30	60–62
4615, 4620	B	145,000	105,000	17	52	300	45	60–62
4615, 4620	C	135,000	105,000	20	55	290	65	59–61
2315, 2320	B	160,000	135,000	11	47	345	35	59–61
2315, 2320	A	95,000	60,000	35	65	195	85	60–62
4820	B	200,000	165,000	14	54	375	28	59–61
2515	B	195,000	160,000	14	50	385	30	58–60
2515	A	145,000	115,000	20	60	270	50	59–61

Heat-treatment: A — Cool from carburizing temperature; reheat to 1525–1550 deg. F., oil quench, reheat to 1400 deg. F., and oil quench.
B — Cool from carburizing temperature; reheat to 35–50 deg. F. above the core critical and oil quench. Treatment best adopted to fine grain steels.
C — Remove from carburizing box or gas carburizing furnace at carburizing temperature and quench in oil.

Treatment "C" is being increasingly used on 3115 and 4615 in tractor plants where gas carburizing is being employed, and is referred to as direct quench practice.

Single and double quench treatment continues to be used on 2315, 4820 and 2515 employed principally in crawler tractor construction.

In processing a carburizing gear, it is the usual practice to normalize the forging blank prior to machining for several reasons. It breaks up coarse grain structure created by high-forging temperatures, effecting a recrystallization to a uniform smaller grain, which tends to minimize distortion in subsequent heat-treatment; and it produces a controlled microstructure conducive to good machining properties and satisfactory finishes. After normalizing and cutting the gear, it is carburized by (a) placing the gear in carbonaceous material and heating 8 to 12 hr at 1650 to 1725 F, (b) gas carburizing at 1600 to 1700 F, or by (c) immersion in molten carburizing salt bath at 1500 to 1550 F. In the large-scale operation of tractor and implement plants the first two methods are most commonly employed, while the third method is well adapted to small plants where space and equipment are limited.

Gears for farming units, as a rule, must have a fairly deep case, consequently depths of carbon penetration are specified from 0.040 to 0.055 in. This provides a carbon content of 0.70 to 0.90 per cent at the surface, which gives good wear resistance.

Following the carburizing operation, the parts must be hardened by heat-treatment. Several practices are followed.

TABLE 2. COMPARISON OF CORE STRENGTH OF 1015, 3115, AND 4815 STEELS GIVEN SINGLE-QUENCH HARDENING TREATMENT

Spec.	Quench temperature	Quenching media	Tensile strength, psi	Yield point, psi	Bhn
1015	1625 F	Oil	80,000	60,000	180
1015	1625 F	Water	105,000	75,000	210
3115	1475 F	Oil	155,000	125,000	335
3115	1475 F	Water	180,000	135,000	360
4815	1460 F	Oil	200,000	165,000	375

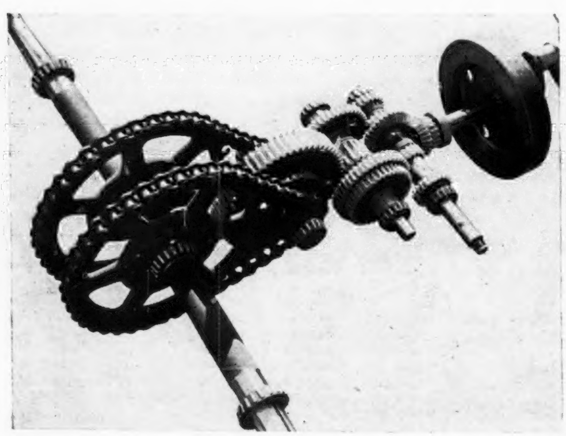


FIG. 2 EXPOSED VIEW OF A WHEEL TYPE TRACTOR DRIVE MECHANISM SHOWING RANGE OF SIZES OF GEARS EMPLOYED

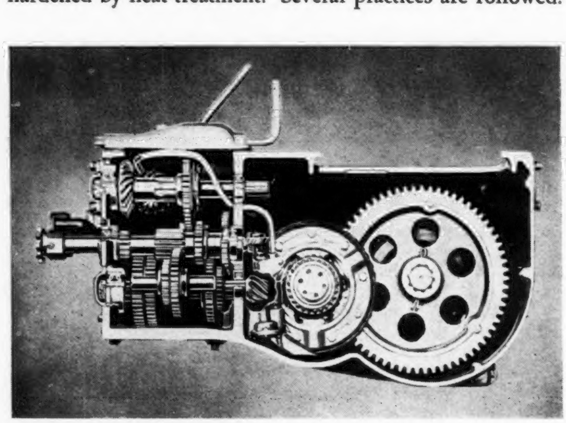


FIG. 3 ANOTHER TRACTOR TRANSMISSION DESIGN UTILIZING LARGE BULL GEARS FOR THE REAR AXLE DRIVE

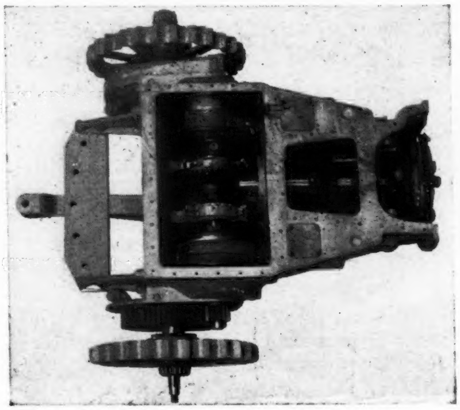


FIG. 4 EXPOSED VIEW OF THE DRIVE MECHANISM OF A TRACK TYPE TRACTOR

The most common, where gas carburizing is used, consists of removing the gears from the furnace at the carburizing temperature and quenching directly in oil. This is referred to as direct quenching and is recommended for tractor gears where certain alloy combinations are used in the steel contributing to low distortion and minimum volume change. It is particularly well suited for the nickel-molybdenum steel, SAE 4615. Direct quenching is sometimes employed where the pack carburizing method is used, but provides difficulties in handling due to the necessity of opening the carburizing boxes at the high temperature. The single-quench treatment is more commonly used in conjunction with the latter method. This consists of allowing the gears to cool down to room temperature in the box, then removing to a furnace at a temperature 30 to 50 F above the critical temperature of the core, and quench in oil. The single quench is most commonly used in farm tool plants, although direct quenching is gaining in certain quarters. It is also employed on the higher alloyed steels where a direct quench might be too drastic, resulting in increased retention of the softer austenite in the case. Single-quench treatment is commonly employed on 3115, 2315, and 4815, while direct quench is used on both 4615 and 3115, although a fair portion of these two steels continues to be hardened by the single-quench method. A third treatment

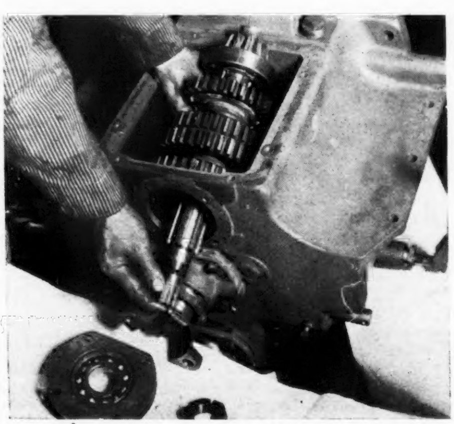


FIG. 5 ANOTHER SET OF TRACTOR TRANSMISSION GEARS TYPICAL OF THE SMALLER GEARS PRODUCED FOR TRACTORS

still used in some quarters is the double quench, in which the gears are removed from the carburizing box after cooling, heated in a furnace to a temperature slightly above the core critical temperature, quenched in oil, reheated to a temperature above the case critical but below the core critical, and oil quenched a second time, followed by the usual low temperature strain relief draw at 300 F.

The effects on core strength as a result of the three types of heat-treatment employed on carburizing grade nickel steels commonly used for tractor and implement gears are presented in Table 3. Treatments A, B, and C refer respectively to double quench, single quench, and direct quench, employing oil as the quenching media. Only one direct-quench treatment (4615-C) is presented, while the single quench values for all grades were included. Attention is called to the casehardness values of 59-62 Rockwell C developed by these treatments. The breaking strength of these hardened cases will vary from 225,000 psi for 3115, to 365,000 psi for 4815, which as a rule provides ample resistance to failure due to concentration of stresses at the surface of gear teeth under bending loads. The greater strength and wear resistance of the case and the higher hardness of the core developed in the above alloy grades, as compared to 1015, permits designing for higher compressive stresses, which today in tractors ranges from 125,-000 psi on transmission gears to as high as 250,000 psi on final drive gears. For all general farm tool purposes the shock resistance and ductility provided by the single-quench treatment is ample.

Almost every type and size of gear is employed in the construction of farm tools, with the exception of the hypoid gear common to automobile construction.

Figs. 2 to 5 illustrate some of the variations in design and size of gears employed in tractor construction.

It is evident from what has already been said in this paper that implement and tractor producers have to watch closely their practice from the forging to the finished product. At the same time, they must select steels which will respond most satisfactorily to the most economical practices. Gears of the type shown in Fig. 5 are being regularly made of 3115, 4615, 2315, and 4815, and meeting heat-treating tolerances under 0.002 in without press quenching. Large nickel-steel ring gears up to 26 and 28 in in diameter, quenched in presses, are holding to 0.003 to 0.006 in in size and out-of-roundness. This has meant greater accuracy in assembling, more perfect meshing, less backlash in operation, fewer rejections in inspection, and more silent operation.

Table 4 presents a list of important tractor gears and the steels employed.

Although discussion has been confined only to gears, there are other parts of a tractor where carburizing steels

TABLE 4. NICKEL CARBURIZING STEELS COMMONLY EMPLOYED FOR TRACTOR GEARS

Transmission gears	3115, 4615, 2315, 4820
Differential pinions	3115, 4615, 2315
Differential side gears	3115, 4615
Power take-off gears	3115, 4615, 4320
Belt pulley gears	3115, 4615, 4320
Drive bevel ring gears	3115, 4615, 2315, 4820
Drive bevel pinions	3115, 2315, 4820
Bull pinions	3115, 4615, 2515
Ring gears (miscellaneous)	3115, 3145, 4615
Crankshaft and camshaft gears	3115, 4615
Sprocket ring gears	3115, 4615, 2315

are considered necessary. Table 5 lists these parts, together with the steels commonly employed. Several shafting parts are to be noted, particularly the transmission spline shaft which must of necessity have a surface resistant to wear of the sliding gears. The alloy is needed for higher torsional strength and greater depth hardening. Slightly higher core strength is gained by using a 0.20 carbon steel in place of 0.15 carbon, especially for the parts subjected to sheer and torsional strains.

In the implement group there are numerous and miscellaneous applications requiring carburized parts. Some typical applications and the steels in use for these parts are presented in Table 6. Only a limited list of these applications are shown in this table, serving only to present typical applications.

Oil Hardening Steel. For parts where tensile and torsional strengths must be of a greater magnitude than provided by the carburizing grades, and where wear resistance is of secondary importance or of no consequence, the so-called direct-hardening steels are used. In steels of this type the carbon content is higher than in the carburizing grades, usually between 0.30 and 0.50 per cent, as already mentioned, and of course are given no carburizing treatment. Steels of this type find their major field of application in the various types of shafting used in farm tools. The nickel steels suitable for this service are SAE 3140, 3240, 3250, 2330, 2345, and 4340. The presence of nickel in medium carbon steels has of course the same effect, as already outlined for the carburizing grades, namely, that along with other properties already mentioned, it increases the toughness and strength and raises the ratio of the yield point to the tensile strength. Other properties imparted of primary importance are as follows:

1 Raises the overall hardness.

2 Increases the depth of hardness in heat-treatment, thereby increasing the overall strength of the part.

3 Increases the torsional strength.

4 Increases the fatigue limit, thereby lessening the danger of failure due to alternating stress.

5 Improves shock resistance.

6 Raises the yield point in bending and in shear.

7 Improves toughness and strength at elevated temperatures up to 800 F.

8 Helps to retain toughness at subzero temperatures.

9 Improves resistance to wear over plain-carbon, direct-hardening steels.

10 Improves machinability within certain hardness ranges and in combination with certain other alloys.

Not all of these points can be discussed in detail; however, the significance of a few of them may be pointed out.

TABLE 5. NICKEL CARBURIZING STEELS EMPLOYED IN THE PRODUCTION OF TYPICAL MISCELLANEOUS TRACTOR PARTS EXCLUSIVE OF GEARS

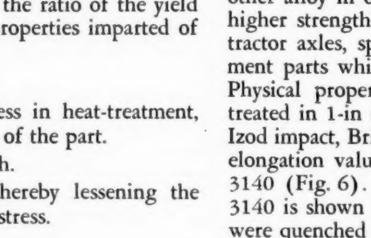
Transmission spline shaft	3120, 4620, 2315, 4820
Piston pins	3115, 2315
Steering worms and sectors	3115
Oil pump shafts	3115
Power take-off shaft (and pinion integral)	3120, 4620, 4320
Straight and tapered roller bearings	3120, 4620
Belt pulley shaft (and pinion integral)	3120, 4620, 4320
Bull pinion shaft (pinion integral)	3120, 4620
Bearing sleeves	3115

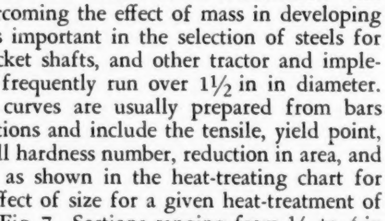
The following represents values for three 0.40 carbon nickel steels of increasing alloy content compared with the plain carbon 1040 grade:

SAE spec.	Tensile strength, psi	Yield point, psi	Elongation, per cent	Reduction of area, per cent	Surface, Brinell
1040 WQ	96,000	61,000	24	49	186
3140 WQ	127,000	97,000	22	55	240
3240 OQ	147,000	118,000	19	47	290
4340 OQ	178,000	153,000	15	46	365

All four grades were treated in 3-in diameter sections, quenched and all drawn at 1000 F. With all processing conditions equal, the effect of increasing alloy content is made evident, both for its effect on increase in strength and also on hardness.

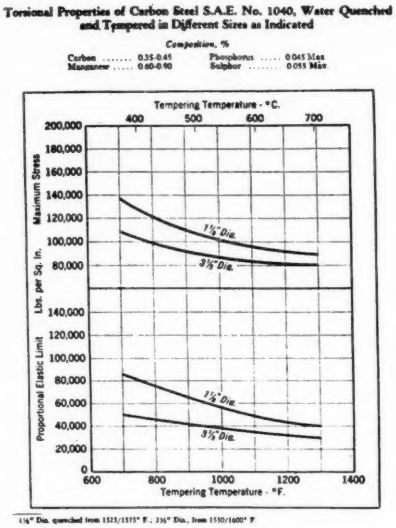
This function of nickel alone or in combination with other alloy in overcoming the effect of mass in developing higher strengths is important in the selection of steels for tractor axles, sprocket shafts, and other tractor and implement parts which frequently run over 1½ in in diameter. Physical property curves are usually prepared from bars treated in 1-in sections and include the tensile, yield point, Izod impact, Brinell hardness number, reduction in area, and elongation values, as shown in the heat-treating chart for 3140 (Fig. 6). Effect of size for a given heat-treatment of 3140 is shown in Fig. 7. Sections ranging from ½ to 4 in were quenched in oil and all drawn at 800 F. Although all values are considerably higher than for plain carbon steel, there is a very noticeable drop in strength in the sizes from ½ to 2½ in for the same steel given the same treatment.





In sections ½" to 2" incl. quenched from 1475/1525° F.; over 2", from 1500/1550° F.

FIG. 6 (LEFT) AND FIG. 7 (RIGHT) MECHANICAL PROPERTIES OF SAE NO. 3140 STEEL



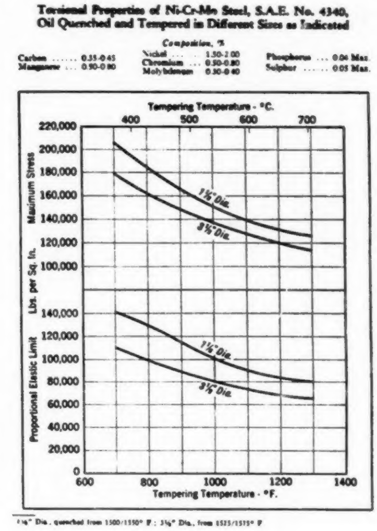


FIG. 8 (LEFT) TORSIONAL PROPERTIES OF SAE 1040 CARBON STEEL. FIG. 9 (RIGHT) CORRESPONDING DATA FOR A 4340 STEEL

Further evidence of the effect of size and the function of alloy in improving properties may be noted in the following:

S.A.E. 4340 STEEL

Bar size, in	Tensile strength, psi	Yield point, psi	Elongation, per cent	Reduction of area, per cent	Bhn
1	212,000	200,000	14	48	430
2	209,000	196,000	12	42	420
4	195,000	176,000	9	38	385

S.A.E. 1040 STEEL

Bar size, in	Tensile strength, psi	Yield point, psi	Elongation, per cent	Reduction of area, per cent	Bhn
1	140,000	105,000	14	45	280
2	115,000	82,000	15	45	230
4	106,000	75,000	14	43	195

in which 1, 2, and 4-in bars of ordinary 1040 and the nickel-chromium-malybdenum steel 4340 were quenched and all drawn at 800 F. This response of 4340 to hardening has resulted in recent years in its adoption in some quarters for tractor axles where the optimum in strength is desired. Another outstanding feature of this steel is its response to machining at high hardnesses. Ordinary turning can be carried out at 388 to 415 Bhn (Brinell hardness number), while splines have been reported to have been milled or hobbed at 450 Brinell under special conditions and at 400 to 430 Brinell in regular production. This has permitted finish machining operations after hardening, aiding greatly in precision assembly. Tractor axles and other shafting, as a rule, are treated to a hardness ranging from 302 to 425 Brinell. The trend has been towards the higher hardnesses, as it has been found that shafts treated to the higher Brinell range have higher endurance limits, lessening the danger of fatigue failures. The endurance limit for the nickel steels has been approximated at 50 per cent of the tensile, whereas the plain carbon steel fatigue limit has been variously placed from 38 to 42 per cent of the tensile strength. The use of nickel not only in raising the fatigue ratio, but also in proportionately increasing the strength in larger sections, has contributed much in overcoming fatigue failures.

The factor of torsional strength is of prime importance in shafting applications as it determines the torque load carrying capacity of the shaft. Torsional values for 1040 and 4340 for $1\frac{1}{8}$-in diameter and $3\frac{1}{2}$-in diameter shafts are shown in Figs. 8 and 9. The first of these figures presents values for 1040 grade water quenched. Torsional ultimate strength and proportional elastic limit are given for various draw temperatures. The second, Fig. 9, presents these same properties for the nickel-chromium-molybdenum steel 4340 submitted to the same treatment. Torsional strength is calculated to pounds per square inch. Proportional elastic limit, the determining value in taking of a permanent set,

TABLE 6. NICKEL CARBURIZING STEELS USED IN TYPICAL FARM IMPLEMENT PARTS

Mower transmission gears	3115, 4615
Grain binder crankshaft sprocket	3115
Grain binder power shaft drive sprocket	3115
Corn binder and picker transmission spur gears and pinions	3115, 4615
Corn binder gather chain sprockets	3115
Power-driven corn sheller gears	3115, 4615
Ensilage cutter gears (all types)	3115, 4615
Roughage mill plate-mill drive gears	3115

TABLE 7. 3140 TRACTOR AXLES

S.A.E.	Diameter at point of failure splined ends, in	Surface Brinell number	Torsional elastic limit, in-lb	Torsional ultimate strength, in-lb	Angle of twist at rupture, deg
3140	$2\frac{1}{2}$	321	242,000	319,000	38
3140	$2\frac{1}{2}$	352	275,000	357,000	34

TABLE 8. DIRECT HARDENING NICKEL ALLOY STEELS USED FOR TYPICAL TRACTOR SHAFTINGS AND MISCELLANEOUS PARTS APPLICATIONS

Parts	Specification				Common Brinell hardness
Engine crankshaft (multiple cylinder)			3140	X-3140	286 - 321
Single-throw, air-cooled engine crankshaft			3135	3140	302 - 335
Transmission countershaft			3140	4340	302 - 385
Power take-off shaft				3140	286 - 335
Belt pulley shaft				3140	286 - 335
Bull pinion shaft		3140	4340	2345	286 - 360
Sprocket shaft (track-type tractor)	3140	X-3140	4340	2345	321 - 425
Rear axle	3140	X-3140	3250	4340	321 - 425
Countershaft axles (jack shafts)				3140	321 - 365
Front axle vertical steering shaft				3140	321 - 365
Water pump shaft (and gears)				3140	480 - 550
Intake valves				3140	300 - 550
Motor studs and bolts		3135	3140	2330	269 - 321
Connecting rod bolts			3135	2330	269 - 321
Body studs and bolts		3135	3140	2330	269 - 321
Hand garden type tractor axles			3140	2345	302 - 360
Camshaft and crankshaft gears				3150	480 - 550
Large bull gears (track-type tractor)				2345	480 - 550
Large bull gears (wheel tractors)				3145	480 - 550

is almost twice that of the plain carbon steel for a given tempering treatment.

Torsion tests on 2½-in diameter 3140 axles, heat-treated to 321 and 352 Brinell, are presented in Table 7 in which the total strength in inch-pounds necessary to break the axle in torsion is given.

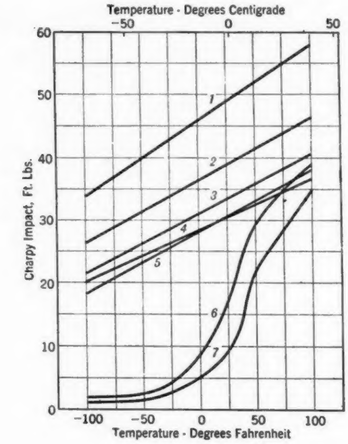
A list of typical tractor direct oil hardening nickel steel parts was assembled for presentation in Table 8. Shafting parts, such as crankshafts, power take-off and belt pulley shafts, sprocket shafts and rear axles must meet severe service conditions and therefore out of necessity in certain designs are made of the alloy steels shown. The more commonly employed Brinell hardness range is also given. SAE 3140 and X-3140 parts are hardened usually within a range of 302 to 365 Brinell, where the 4340 grade is treated to 350 to 425 Brinell, depending on the loads to be carried and the relative amount of ductility and toughness needed.

Connecting rod, motor, and body studs and bolts are usually made of 3135, 3140, or 2330 and are treated to a 269 to 321 Brinell hardness range. In addition to providing excellent ductility coupled with relatively high strength, these steels retain a relatively high proportion of their strength and ductility at the temperatures commonly encountered in ordinary motor operation. This factor is one contributing to the universal use of 3140 for motor intake valves. On the other end of the temperature operating range, particularly during zero and subzero weather, the nickel steels are well suited for parts which may be subject to sudden shock under these conditions. To illustrate this Fig. 10 has been included to present the behavior of plain carbon steel subjected to impact tests at temperatures ranging from +100 F to −100 F. The values for plain carbon steels as shown in curves 6 and 7 indicate the rapid drop in impact as the temperatures approach 0 F, whereas the nickel containing steels in curves 1 to 5 had no sudden drop with a lowering of temperature. Although these values are for normalized steel, the same characteristics hold for the quenched and drawn treatment.

Although it is more common in the farm tool field to employ carburized steels, several gear parts have already been listed as being made of direct-hardening nickel steels. This practice is carried out in a few applications where a moderate amount of wear resistance is needed and where pitting fatigue is not a major factor, but where resistance to shock, ductility, and load carrying capacity must necessarily be of a higher order than provided by plain 0.40 and 0.50 carbon steel. The grades best suited for this type of service are 3140, 3150, 3250, 4650, and 2345, all of which have been successfully used for both tractor and implement gears. As a rule, practice involves an oil quench

TABLE 9. DIRECT-HARDENING NICKEL STEELS USED IN MISCELLANEOUS FARM IMPLEMENT PARTS

Parts	Specification	Common Brinell hardness
Hammer mill drive shafts	3140	288 - 340
Hammer mill flywheel hammer	3140, 3150	450 - 550
Ensilage cutter conveyor and feed roll shaft	3140	288 321
Ensilage cutter transmission speed change shaft	3140	288 - 321
Ensilage cutter flywheel shaft	3140	288 - 321
Corn husker bevel gears	3150, 4640	480 - 550
Corn husker bevel pinion and shaft	3150, 4640	480 - 550
Corn husker ratchet tooth gear	4640	480 - 550
Corn husker butting wheel	4640	450 - 550
Silage cutter feed change shafts	3135, 3140	288 - 321
Mower transmission shafts	3140	288 - 321
Corn picker sprocket drive shaft	3140	288 - 321



Curve	Material	% C	% Ni	Heat Treatment	Direction
1	Pipe	0.14	2.33	Normalized	Longitudinal
2	Plate	0.25	2.40	Normalized	Longitudinal
3	Plate	0.25	2.40	Normalized	Transverse
4	Casting	0.20	2.40	Normalized	....
5	Weld	0.10	1.60	Stress Relieved	....
6	Plate	0.09	....	Normalized	Longitudinal
7	Plate	0.24	....	Normalized	Longitudinal

FIG. 10 EFFECT OF TEMPERATURE ON THE IMPACT RESISTANCE OF CARBON AND NICKEL STEELS

followed by a low-temperature draw in the neighborhood of 300 to 450 F.

Table 9 presents a list of the steels in use at the present time on various implement shafting and gear parts. The 0.40 carbon nickel-molybdenum steel on the several corn husker parts was chosen for response to taking a light cyanide case (.008 in) and minimum distortion in heat-treatment. Brinell hardness ranges to which the parts are commonly treated are also included.

Table 10 presents a resume of the general property requirements of tractor parts, reprinted from the February 1939 issue of "Product Engineering".

Plow disks have been made within recent years of a high-carbon nickel-chromium steel, 3160, which has met wear, shock, and scouring requirements under the more severe plowing conditions. These disks (Fig. 11), which are oil-hardened to a Brinell range of 400-440, possess approximately twice the resistance to shock provided by the plain carbon disk material, SAE 1080. Unnotched impact and cold bend tests, the most accurate tests comparable to actual service, have been made on both the 3160 and the unalloyed 1080, values for the former being presented in Fig. 12.

Unnotched longitudinal Charpy values for 3160 at 420 Brinell are slightly better than 250 ft-lb. For 1080 at the same hardness the unnotched impact is about 140 ft-lb. Angle of cold bend for 3160 at this hardness is about 65 deg before fracture takes place, while for 1080 it is about 35 deg. Standard notched Charpy for 3160 is about twice that of 1080.

This unusual increase in resistance to shock imparted to disks by the addition of nickel and chromium has made possible faster plowing speeds and good performance in rocky soil where plain carbon steel has failed to stand up. It has proven its adaptability to plowing with track-type tractors where the going is tough.

Austenitic Steels. Only passing reference is made to this group of highly alloyed steels which includes 18-8 chrome-nickel stainless used for miscellaneous corrosion resistance

TABLE 10. ALLOY STEELS AND PROPERTY REQUIREMENTS FOR TRACK AND WHEEL TYPE TRACTOR PARTS

Name of Part	High Yield Point in Tension	Resistance to Shock (Impact)	Impact Resistance at Low Temp.	Resistance to Wear	Resistance to Fatigue	Resistance to Pitting Fatigue	High Yield Point in Torsion	High Yield Point in Compression	High Torsional Impact	Toughness at Ordinary Temp.	Toughness at Elevated Temp.	High Yield Point in Bending	Resistance to Seizing	Ductility	High Yield Point in Shear	Depth Hardening in Heat-Treat.	Min. Distortion in Heat-Treat.	S. A. E. Alloy Steel Specifications Commonly Used (0.15 and 0.20 carbon grades carburized; and 0.30 to 0.50 carbon oil hardened)
Motor crankshaft	★			★	★		★		★	★			★	★		★	★	3140, X-3140
Piston pins		★		★	★			★			★		★		★			3120, 4620, 2315
Intake valves				★	★						★		★				★	3140
Exhaust valves				★	★						★		★				★	21% Cr., 12% Ni.
Clutch hub and joints					★		★		★	★				★				3140
Clutch shaft					★		★		★	★				★				3140, X-3140
Transmission gears	★	★	★	★		★		★		★		★		★			★	3120, 4620, 2315, 2345, 4820
Transmission spline shaft			★	★	★		★		★	★			★		★		★	3120, 4620, 3140, 2315, 4820
Transmission countershaft					★		★		★	★								3140, 4340, 4820
Power take-off shaft	★		★		★		★		★	★		★				★		3140, 3120, 4620, 4320
Power take-off gears	★	★	★	★		★		★		★		★		★			★	3120, 4620, 4320
Belt pulley shaft	★		★		★		★		★	★		★				★		3140, 3115, 4620, 3120, 4320
Belt pulley gears	★	★	★	★		★		★		★		★		★			★	3120, 4620, 4320
Differential shaft				★	★		★		★	★			★		★		★	3120
Differential side gears	★	★		★		★		★		★		★		★			★	3120, 4620
Differential pinion	★	★		★		★		★		★		★		★			★	3120, 4620
Drive bevel ring gear	★	★	★	★		★		★		★		★		★			★	3120, 4620, 2315
Main drive bull gears	★	★	★	★		★		★		★		★		★			★	3145, 3120, 4620, 2345
Bull pinion	★	★	★	★		★		★		★		★		★			★	3120, 4620, 2515, 2315, 2345
Bull pinion shaft			★		★		★		★	★		★		★		★	★	3140, 3120, 2345
Sprocket shaft	★		★		★		★		★	★		★		★		★	★	3140, X-3140, 2345
Rear axle	★		★		★		★		★	★		★		★		★	★	3140, X-3140, 3250, 4340
Rear axle ring gears	★	★	★	★		★		★		★		★		★			★	3145, 3120, 4620
Jackshaft	★		★		★		★		★	★		★		★		★	★	4620, 3140
Countershaft axles	★		★		★		★		★	★		★		★		★	★	3140, 4620
Steering knuckle pin		★	★	★	★			★		★		★	★		★			3120, 4620
Front axle vertical shaft	★				★		★		★	★		★		★			★	3140
Steering gears and sectors		★	★	★				★		★		★						3120
Motor studs and bolts	★										★		★	★	★			3135, 3140, 2330
Connecting rod bolts	★	★			★						★			★				3140, 2330
Body studs and bolts	★	★	★		★			★		★		★		★				3140, 2330
Roller bearings				★		★		★		★	★		★			★	★	3120, 4620

applications and 21-12 chromium nickel heat-resisting steel for motor exhaust valves. The 18 per cent chromium, 8 per cent nickel stainless steel finds a much larger field of application in dairy machinery parts, and although applying to the general scope of agricultural activities, is outside the field covered by this paper.

Plating. In closing the portion of this paper on steels, attention is called to a recent development of a plating process which is employed on a miscellaneous list of parts where mild resistance to rusting is desired such as wire, fence posts, sheets used in combines, threshers, hoppers, bins, and fertilizer and manure spreaders. The process involves the electrodeposition of nickel on the part to be protected, followed by a layer of electrodeposited zinc over the nickel. After plating the object is heat-treated to effect an alloying of the zinc and nickel layers which provides corrosion resistance reported to be superior to the straight hot-dip zinc coating and at the same time is sufficiently ductile to permit cold forming, necessary to satisfactory fabrication of the part.

FIG. 11 NICKEL-CHROMIUM STEEL DISKS USED ON A DISK PLOW

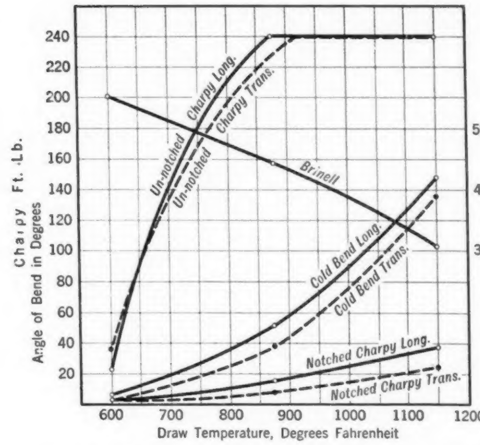


FIG. 12 COLD-BEND AND CHARPY IMPACT VALUES FOR 3160 NICKEL-CHROMIUM STEEL

Wear in Sprayer Nozzle Disks

(Continued from page 394)

be readily seen in the photograph of a complete disk taken from the whirl plate side. It is also plainly shown in all macrophotographs of cross-sectioned disks.

Sharp edges at the inside of the disk orifices were observed to be rounded off in less than one hour's run in test No. 3.

The flow of the liquid through the orifice is apparently contracted a sufficient amount to prevent any wear beyond the rounded edges. This means that disk openings do not wear larger in diameter as has been stated by many authorities. The diameter of the hole at the outside surface of the disk is the last part of the orifice to change in size.

Wear on the inside edges of the orifice not only increased the rate of discharge but also changed the character of the spray cone, as can be seen in the photograph of a new and worn disk in the Hardie broom.

Advances in Sanitary Milk Production in California

(Continued from page 398)

the selection of construction materials and paint, and in the attention given to making the surroundings clean and attractive.

In one area of concentrated commercial production, voluntary participation of almost all of the producers in a community-sponsored contest has turned an ordinary appearing, and rather run-down district into an attractive, prosperous-appearing locality. The competitive spirit engendered has led some builders to incorporate glass brick facades on their milk houses, fish ponds in their formal entrance landscaping, and other features which cannot be justified solely on the basis of sanitation. Similar interest has also been apparent in the emphasis placed by retail dairies, especially those retailing through their own stores or through "milk bars" located at the dairy, on attractive layout and landscaping.

"A National Terrace Classification"

To the Editor:

IN AGRICULTURAL ENGINEERING for March 1939 (vol. 20, no. 3), C. L. Hamilton proposed a national terrace classification that has much merit. It may be recalled that in this classification, which is based on functional characteristics, three major types are recognized, viz., drainage, absorptive (or retention), and bench. Accordingly, Hamilton proposed these terms for the three classes of terraces as distinguished by primary function: (1) drainage type terraces, (2) absorptive type terraces, and (3) bench type terraces. While the basic scheme followed by Hamilton in classifying terraces according to primary function appears to be sound and adequate in principle, a year's experience in attempting to apply the classification has led to the conclusion by this writer that it needs modification. The object of this discussion is to present suggestions for the modification of Hamilton's proposed national terrace classification.

There seems to be little justification for the insertion of the word "type" in the terms proposed by Hamilton. Such usage appears redundant. In other technologies unnecessary words as applied to technical objects and concepts have nearly always been ignored and finally dropped. In the classification being discussed the word "type" might just as well be dropped now, as it will inevitably be deleted in practice.

Hamilton notes that there are many forms of terraces in each of his major classes. No specific provision appears to be made for designating these forms, although there is need for the sake of clarity and accuracy that they be specifically classified. To fill this need, I propose the addition of a qualifying prefix to designate specifically the particular form of terrace. Thus the terrace known as the Nichols terrace would be designated the "Nichols drainage terrace". Similarly the Mangum terrace would be designated the "Mangum drainage terrace". A partial list of such terrace designation follows:

I. Drainage terraces
   - Nichols drainage terrace
   - Mangum drainage terrace

II. Retention terraces
   - Retention terrace (to which may be prefixed such explanatory adjectives as "open-end" or "closed-end")
   - Dickson retention terrace

III. Bench terraces
   - Preformed bench terrace
   - Balk bench terrace
   - Reddick bench terrace
   - Rock-defended (or masonry-defended) bench terrace
   - Javanese bench terrace
   - Level-basin bench terrace.

It is not the purpose of this letter to define in detail the terraces named above. Some of them will be readily understood. Others are new or coined names for special kinds of terraces. The term "Dickson retention terrace" is proposed for the syrup-pan terrace as developed by R. E. Dickson in West Texas. The term "balk bench terrace" is proposed for the bench terrace found commonly in the southeastern United States on critical slopes. This terrace has been described and illustrated by Hamilton in the U.S.D.A. Farmers' Bulletin 1789 (pp. 19-21). Balk as used in this term is synonymous with plant barrier or vegetative barrier. The design and construction of the Reddick bench terrace has been well described by Hamilton on page 20 of the bulletin just referred to. The term "Javanese bench terrace" is applied to one of the numerous bench terraces developed in the Dutch East Indies. It differs from most of the commonly known bench terraces in that part of the soil is moved uphill.

There are many forms of bench terrace in addition to those listed here. From the fact that bench terraces have been widely employed, both in ancient and modern times, in many parts of the world, their potential usefulness in soil defense in the continental United States is larger, in the opinion of this writer, than would seem granted by Hamilton.

There are real advantages to affixing the name of an engineer or a soil conservationist or a label denoting form or construction method to a terrace designation. Within a given region, standards of construction and soil and slope limitations may then be established for the particular terrace thereby designated. A terrace ill planned or poorly constructed so that it does not meet such specifications may be condemned at once just as any other faulty engineering installation would be condemned. Lacking specific designations, specifications cannot readily be established or applied.

MAURICE DONNELLY

Project leader, cooperative hillculture research (Riverside, Calif.), University of California and U. S. Soil Conservation Service.

Mosquito Control in India

WITH wide experience in mosquito and malarial control investigations in the Balkan peninsula in Europe, Fred W. Knipe (Mem. A.S.A.E.), agricultural engineer for the Rockefeller Foundation, engaged in similar investigations in India, writes the Secretary of A.S.A.E. on the status of his present work. His letter follows:

"We have not had as spectacular results here in our mosquito and malarial control investigations as we had in some parts of Europe, but we are making progress. Our worst difficulty here is waste irrigation water which runs wild everywhere. About 60 per cent of all irrigation water is wasted; that is a government engineer's figures, not mine. Rice is our principal crop, but, oddly enough, our malaria-carrying mosquito does not develop in rice fields. If it did, there might be very few people alive in South India.

"We have had one amazing success though. That has been with preventing malaria transmission by spray-killing adult mosquitoes. We thought it could not be done in South India. We tried it just to rule it out. To our amazement, we have reduced transmission to zero and old malaria from around 60 per cent of the population to less than 10 per cent, all in two years. But the cost is high. So I spent most of my vacation in the U.S.A. trying to look up equipment that would make the process cheaper. This year we believe we will cut costs more than 50 per cent.

"This year for the first time we are attempting a small program of intermittent irrigation on a specified area. In this we are cooperating with the public works department. But farmers are stubborn in India just as in America. So they do not take kindly to intermittent irrigation. They want water where and when they want it, which means *every* day."

NEWS

"As Maine Went . . . . ."

By H. N. Stapleton

"AS Maine goes" will be mentioned in other instances this fall, but it should be reported how Maine "went to town" in playing host to the A.S.A.E. North Atlantic Section and the New England Rural Electrification Institute, August 27 to 30.

M. G. Huber & Co., may be said to have included the University of Maine staff and the state conservation department from the way everyone was treated. By Thursday it was the consensus of the group that the delay in picking exact dates for the meeting earlier this year had been due to the inability of the weather man to give John Leland a satisfactory guarantee. It was apparent that Mr. Leland in true Yankee form got both the guarantee and the results.

Estabrook Hall, the new women's dormitory, was check-tested for its first season in true engineering fashion. Seconds and thirds did not dismay the dininghall staff and the chefs. The lounges and meeting rooms were very pleasant, and there were easy chairs for comfort or for sleeping through the papers, if you chose to do that instead of retiring to your room to a more comfortable bed. There were outlets near mirrors in the baths that did duty for electric shavers. There were ash trays in the rooms. The only voiced criticism heard at all was that the shower heads were placed a little low for tall men to wash their ears, and Frank J. G. Duck, alias Ira Miller, forgot to telescope sufficiently to avoid a doorcheck a couple of times.

The registered attendance was a little smaller than usual which was probably expected considering the time of the year, dates near the A.S.A.E. Industry Seminar, and the rush of work this year has brought many of our members. It is worthy of note, however, that nearly three-fourths of the members attending had their families with them, and the meeting began to take on the tone of one of those kind of house parties you'd like to have some day that would bring together all of the most congenial of your very best friends. The ladies had a little vacation by way of doing exactly what they pleased and every contact among members was a challenge to swap information and ideas.

The banquet was offered as proof that you haven't eaten lobster until you have eaten it in Maine. Official Photographer Parker Hess was able to get some evidence in the cases of Toastmaster Joe Webb and F. L. Rimbach. Toastmaster Webb, lighting a cigar the size of a ball bat and then using it as a gavel, was able to call on dignitaries present and limit them to a "My Friends" or a bow of acknowledgment, thereby maintaining right-of-way for the principal speaker, Mr. A. L. T. Cummings, who needed no support or rebuttal to prove that a story told about a French-Canadian comes to its full flower only from the lips of a Saco River Yankee.

At the business meeting the usual order of business prevailed, and the treasurer reported the Section a going concern with money in the bank. Election of officers resulted in the choice of Frank H. Hamlin as chairman, Maurice W. Nixon as vice-chairman, wi h H. N. Stapleton continuing as secretary-treasurer. Next year's nominating committee, also elected, consists of Geo. W. Kable, chairman; Wallace Ashby, and J. H. Bodwell. Russell H. Gist received many seconding speeches favorable to his nomination of West Virginia as the place to receive first consideration by the executive committee as the location of the 1941 meeting of the Section.

Some of the papers presented may be published in AGRICULTURAL ENGINEERING but if copies of any of them are desired, requests should be sent to M. G. Huber, extension agricultural engineer, University of Maine, Orono, before December 1. Use your copy of the program as a check list or refer to AGRICULTURAL ENGINEERING for August.

A.S.A.E. Meetings Calendar

December 2-6—Fall Meeting, technical divisions, The Stevens, Chicago, Ill.

Februray 5-7, 1941—Southern Section Meeting, Atlanta, Ga.

June 23-26, 1941—Annual Meeting, Knoxville, Tenn.

Industry Seminar Has Successful Program

THE 1940 Industry Seminar, sponsored by the American Society of Agricultural Engineers, with the cooperation of six companies of the farm equipment industry, was held September 3 to 11, inclusive.

The group included 117 persons registered, made up of junior and senior students in agricultural engineering at state colleges and universities, staff members of agricultural engineering departments, faculty representatives of farm management departments, four representatives of the U. S. Department of Agriculture, and five Latin-American representatives. Thirty-one states were represented, namely, Alabama, Arizona, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, and Wisconsin, and two provinces of Canada, Alberta and Saskatchewan.

The six cooperating manufacturers included, in the order in which they acted as hosts to the Seminar group, Minneapolis-Moline Power Implement Co., Minneapolis; Deere & Co., Moline; Caterpillar Tractor Co., Peoria; International Harvester Co., Chicago; J. I. Case Co., Racine, and Allis-Chalmers Mfg. Co., Milwaukee. The Seminar group spent a day at each of the places mentioned, where they were shown a wide variety of interesting and informative factory operations in the production of modern farm tractors and other machines and implements. A feature of each day's program was a number of talks by key men in the different companies dealing with the engineering, manufacturing, distribution, and servicing phases of the farm equipment industry. The talks, together with the trips through the factories, were particularly interesting and gave the group an excellent insight into the problems and methods of producing modern farm machinery. In the space of one week, students and instructors received a practical education in recent developments and the most up-to-date methods in the agricultural equipment industry, which would be impossible to obtain in any other way in so short a time. (Continued on page 412)

1940 A.S.A.E. INDUSTRY SEMINAR GROUP OF INSTRUCTORS AND STUDENTS

Industry Seminar Has Successful Program

(*Continued from page 408*)

During the first half of the trip, the group traveled and were quartered in Pullman cars, including five sleepers with a club car as a "social center". Busses were used for transportation between Chicago and Racine and Milwaukee. Harry G. Davis of the Farm Equipment Institute acted as special representative of the participating companies, having charge of transportation and accommodations. I. D. Mayer of Purdue University, chairman of the A.S.A.E. committee directly responsible for the Seminar, represented the Society. Also present on the trip was the president of the Society, E. E. Brackett, head of the agricultural engineering department, University of Nebraska.

Advisory Committee on Engineering Defense Training Appointed

APPOINTMENT of an Advisory Committee to the U. S. Office of Education on Engineering Training for National Defense was announced recently by John W. Studebaker, U. S. Commissioner of Education.

Members of this committee represent leading engineering schools and will advise on matters of policy affecting the national defense training program in engineering schools. The chairman is Andrey A. Potter, dean of engineering, Purdue University.

Personals

John F. Cykler has been appointed instructor and research assistant in agricultural engineering at the University of Wyoming at Laramie. He was graduated from the University of California in June of this year.

J. B. Kelley has compiled a booklet of "Plans for Dwellings and Farm Buildings in Kentucky," published by the Extension Division, College of Agriculture, University of Kentucky.

J. R. Orelind, formerly chief engineer, International Harvester Co., Canton Works, has been promoted to supervisor of engineering, general office, International Harvester Co., 180 N. Michigan Ave., Chicago.

Russell R. Poynor was recently appointed instructor in agricultural engineering at Purdue University. Prior to his appointment he held a similar position at Utah State Agricultural College.

June Roberts has been appointed the new rural electric investigator of the Washington Committee on the Relation of Electricity to Agriculture, succeeding W. A. Junnila, and will be stationed at the State College of Washington at Pullman. Previously Mr. Roberts was instructor in agricultural engineering at Kansas State College.

Jefferson B. Rodgers is now an associate agricultural engineer of the U. S. Bureau of Agricultural Chemistry and Engineering, and is doing rural electrification research and investigation work on the La Farge Farms project at La Farge, Mo. He was formerly instructor in agricultural engineering and assistant agricultural engineer in the experiment station at the University of Idaho.

G. E. P. Smith reports on "The Groundwater Supply of the Eloy District in Pinal County, Arizona," in Technical Bulletin No. 87 of the Arizona Agricultural Experiment Station.

Student Program at 1940 A.S.A.E. Annual Meeting

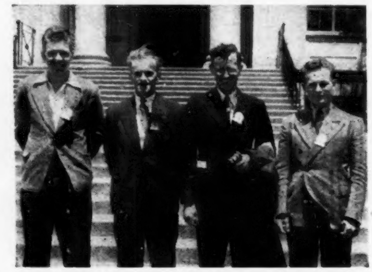
By Earle Cox

FORTY representatives of student branches of the American Society of Agricultural Engineers from the United States and Canada participated in the student program at the A.S.A.E. annual meeting, June 17 to 20, at Pennsylvania State College. The students from the University of Saskatchewan traveled 2,300 miles to attend the meeting. Representatives of the A. and M. College of Texas came nearly as far, traveling 2,000 miles before arriving at Penn State. Many of the students came a thousand or more miles in order to be present.

The scope of the territory covered by agricultural engineering is evidenced by the fact that twelve states and one province in Canada were represented. From west to the Dakotas, south to Texas, east to Pennsylvania, and north to Saskatchewan, students came for a chance to find out about agricultural engineering progress and to meet engineers from other places.

The four new officers of the National Council of A.S.A.E. Student Branches are from widely separated schools. They are: President, David W. Chandler, University of Tennessee; first vice-president, Don L. Trapp, University of Saskatchewan; second vice-president, John H. Wessman, Iowa State University; secretary, Earle F. Cox, University of Nebraska.

Of particular interest to the students is the presentation at the annual meeting of the F.E.I. cup, donated each year by the Farm Equipment Industries and awarded by the A.S.A.E. to one of its student branches. This year the student branch at the University of Nebraska received the award. This increases the number of branches that have received the award to four. Other branches who have received the award in the past are Iowa State College, University of Georgia, and Ohio State University.



NEW OFFICERS, NATIONAL COUNCIL OF ASAE STUDENT BRANCHES

Left to right, Earle Cox (Nebraska), secretary; Don Trapp (Saskatchewan), first vice-president; Dave Chandler (Tennessee), president; and John Wessman (Iowa), second vice-president

During the meeting student discussion periods were held in order to discuss problems in agricultural engineering and in A.S.A.E. student branches. Financial problems in the various branches provided an interesting discussion. The problems relating to the branches were much the same, but those relating to agricultural engineering varied with the different states. There was little in common in the problems of the southern and the northern engineer.

To many students the most interesting session was the one in which prominent agricultural engineers discussed employment in different fields. L. J. Fletcher of the Caterpillar Tractor Company spoke on "The Responsibilities of an Agricultural Engineer", and L. A. Jones discussed "Drainage as a Phase of Soil Conservation." These talks were followed by three others which held particular interest for seniors or graduates seeking employment.

A. P. Yerkes of the International Harvester Company spoke on "Opportunities for an Agricultural Engineer with a Farm Equipment Company." He pointed out that the farm equipment companies could only employ a limited number of graduates each year. Therefore graduates should be qualified to fill jobs in other kinds of work.

G. B. Hanson of the Portland Cement Association presented a new field for the employment of agricultural engineers. He stated that in the road-building industry agricultural engineers are in demand at present.

J. P. Schaenzer of the Edison Electric Institute told of new openings for agricultural engineers. He believed that in rural electrification more and more agricultural engineers will be employed. Things of the future were brought back to the present by H. G. Davis of the Farm Equipment Institute. He spoke on "Present Trends in Agricultural Engineering." Of course these present trends will determine the agricultural engineering of the future.

After the interesting discussions, the election, and the addresses of the "real" engineers, the students were ready to depart for homes widely scattered over the United States. Following the farewells, the students left with a "So long, see you next year in Tennessee."

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the September issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

V. W. Anderson, inspection supervisor, Farmers Mutual Reinsurance Co. (Mail) 608 S. Dearborn St., Chicago, Ill.

James C. Beatty, assistant agricultural engineer, utilization division, Rural Electrification Administration, U. S. Department of Agriculture, 2000 Massachusetts Ave., Washington, D. C.

S. B. Bowers, Jr., engineer, McConnel, Hammond & Long, 3419 N. Main St., Columbia, S. C.

Herbert B. Erickson, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Culbertson, Mont.

Wilbur B. Larkin, chief engineer, Butler Manufacturing Co., 13th and Eastern, Kansas City, Mo.

L. O. Palmer, assistant extension agricultural engineer, Mississippi Extension service, State College, Miss.

Oliver W. Steele, owner, Oliver Manufacturing Co., 1409 S. Eighth St., St. Louis, Mo.

J. V. H. Torner, rural supervisor, Monongahela West Penn Public Service Co. (Mail) Box 451, Elkins, W. Va.

TRANSFER OF GRADE

J. C. Oglesbee, Jr., extension agricultural engineer, agricultural extension service, University of Georgia. (Mail) Tifton, Ga. (Junior Member to Member)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

LESPEDEZA SEED-HARVESTING EQUIPMENT, *H. A. Arnold.* Tenn. Sta. (Knoxville) Bul. 171 (1940), pp. 20, figs. 7. This bulletin reports upon studies of seed-pan attachments on mowers, both of homemade and of commercially available types, as compared with threshing, combining from the windrow, or direct combining. In general, these tests indicated that the use of a lespedeza seed-harvesting attachment would be profitable where seed is not harvested by the direct combine method.

All harvesters of the pan type were found to be comparatively low in first cost. They harvest only fully ripened seed. Unlike threshers and combines, they left dodder seed unhulled, so that it was more easily cleaned out of lespedeza seed, especially Korean. Threshing or combining lespedeza from the windrow usually resulted in considerable windrow losses. Seed-harvesting attachment units on mowers greatly reduced these losses. Direct combining eliminated the windrow losses. In the harvesting of short lespedeza or lespedeza on rough land, cutting with a mower resulted, under ordinary conditions, in comparatively low stubble losses, even when direct combining was practiced.

The harvesting-attachment units collected only the seed that shattered readily from the straw. In the harvesting of Korean lespedeza, early in November, from 40 to 60 per cent of the seed passing over the cutter bar was collected by the attachments. In the case of Kobe, about two-thirds of the seed was collected and about one-third was lost with the straw (straw and separating losses). The amount of loose seed lost with the straw through poor separation was small in the case of Korean, but was about 16 per cent in the case of Kobe, because of the small perforations used on the commercial attachment units. In field tests of two commercial machines, of the rake and of the slat-conveyor types, the latter was slightly more efficient in thin to medium stands of lespedeza, the former in thick, rank growths. Seed lost ahead of the mower cutter bar varied from 60 to 166 lb per acre, or from 13 to 32 per cent of the seed on the stalk. A sharpened sickle reduced the cutter bar losses by two-thirds.

RUBBER-TIRING FARM MACHINES, *D. K. Struthers and A. H. Bennett.* Iowa Sta. (Ames) Bul. P9, n. ser. (1940), pp. 273-287, figs. 18. In a brief statement concerning the advantages of rubber tires over steel wheels for farm machines, this bulletin notes an experiment in which at 2.5 miles per hour a steel-wheeled machine received approximately 6 times as many shocks in passing over 5 miles of graveled road as did a rubber-tired machine of the same model. With the steel wheels there were 4,431 shocks ranging from 350 to 1,988 lb force, while the rubber-tired machine received only 709 shocks ranging from 350 to 1,288 lb force. At 5 mph the rubber-tired machine received only 528 shocks compared with 18,261 for the steel-wheeled machine, or 34.5 times as many. The shocks ranged from 1,050 to 3,425 lb force for each machine. Two manure spreaders of the same model were used in this experiment.

A method for cutting out the hub and spokes of steel wheels and welding them into drop-center rims is described. Each stage of this operation is illustrated by a photograph.

MECHANIZED DUSTING EQUIPMENT FOR PEA WEEVIL CONTROL, *E. N. Humphrey.* (Coop. U.S.D.A.) Idaho Sta. (Moscow) Bul. 234 (1940), pp. 11, figs. 28. From a study of the effectiveness, cost of operation, and other factors involved in the use of 13 machines operating under commercial conditions, it was found that no material difference resulted in the use of low and high-pressure machines, nozzle velocities varied greatly with little appreciable difference in effectiveness, and blower power requirements ranged from 1.5 to 8 hp, depending upon the type of blower and accompanying mechanism.

Dusters were mounted on 2 or 4-wheel carts pulled by team or trailed behind a truck or tractor, or were mounted on wheel tractors, crawler tractors, or trucks. They were driven by power take-offs from the tractors or by auxiliary motors. Distribution nozzles and pipes were carried on long booms, varying from 30 to 60 ft. The outer ends of the booms were supported on caster wheels or suspended from a boom tower. Use of the castor wheel required one less man for operation and maintained the hood at a fixed height above the pea vines. Each machine protected an average of approximately 1,093 acres by dusting from one-third to one-fourth of each field. The most satisfactory method of transportation on steep or hilly ground was the track-type tractor.

Cost for operation varied from 21 to 38 cents per acre. Twenty pounds of dust, the minimum applied, cost $1.50 per acre. The cost of custom dusting averaged 50 cents per acre for machine operation.

Actual field damage from the use of dusting equipment varied from 1.99 to 3.5 per cent. The greatest amount of damage was done by horse-drawn equipment or wide-tread track-type tractors.

PUTTING DOWN AND DEVELOPING WELLS FOR IRRIGATION, *C. Rohwer.* U. S. Dept. Agr. Cir. 546 (1940), pp. 86, figs. 41. It is pointed out in a brief introduction that for irrigation, as distinct from domestic supply, wells capable of supplying large quantities of water at a reasonable cost are required. This circular is intended for the information of farmers, well drillers, and others concerned with the construction of pumping plants for irrigation, who should be familiar with all the factors involved in the production of a satisfactory well.

The principal phases of the subject here dealt with are factors affecting the feasibility of pumping plants, including legal status of pumping from wells, water supply, pumping lift, and well contract; factors affecting flow of ground water into wells; hydraulics of wells, under which heading are given formulas for the approximate computation of the discharge in gallons per day of the artesian and nonartesian types; battery wells; interference of wells; test-hole drilling by the sand-bucket, standard-tool, hydraulic-rotary, jetting, hollow-rod or self-cleaning, and auger methods; irrigation wells and their construction by various methods; gravel-envelope or gravel-screen wells; development of wells by pumping, by surging, with air, by backwashing, and with solid carbon dioxide; testing wells; and the cost of constructing wells in 12 western states.

EROSION AND RELATED LAND USE CONDITIONS, U. S. Dept. Agr., Soil Conserv. Serv. [University Lake Watershed], 1939, pp. 16, fig. 1, maps 2; [Spartanburg Municipal Reservoir Watershed], 1940, pp. 16, fig. 1, maps 2; [Lloyd Shoals Reservoir Watershed], 1940, pp. 26, pls. 4, fig. 1, map 1; [Lake Michie Watershed], 1940, pp. 19, pls. 3, fig. 1, maps 2. Conservation surveys are reported as follows: On the University Lake Watershed, Chapel Hill, North Carolina, by T. C. Bass and I. L. Martin; on the Spartanburg Municipal Reservoir Watershed, South Carolina, by T. C. Bass and I. L. Martin; on the Lloyd Shoals Reservoir Watershed, Georgia, by P. H. Montgomery; and on the Lake Michie Watershed, near Durham, N. C., by I. L. Martin and T. C. Bass.

IRRIGATION AND DRAINAGE RESEARCH, *O. W. Israelsen.* Farm and Home Sci., Utah Sta. (Logan), 1 (1940), No. 2, p. 8, fig. 1. This is a popular summary of the objectives of the irrigation and drainage research of the station. Under the primary objective of the more efficient and economical utilization and control of the State's water resources are listed 10 secondary objectives constituting essential phases of the solution of the primary problem.

ADJUSTING CORN PLANTERS AND LISTERS FOR SORGHUMS, *L. W. Hurlbut.* Nebraska Sta. (Lincoln) Cir. 64 (1940), pp. 14, figs. 10. Directions for determining the number and size of holes to be drilled in a blank seed plate for the proper seeding of sorghums with a corn planter or lister previously used for corn seeding are given. This procedure is recommended in preference to any attempt to adjust the seeding rate and spacing of a corn seed plate because it was found in experimental trials that corn plates tended to produce a seeding rate of from two to three times the recommended weight of seed per acre. If a corn plate is used, some device for spreading the seed along the row should be added because of the large number of the smaller sorghum seed dropped from each cell. The spacing, drilling, and reaming of the holes for a sorghum plate is fully dealt with, the shaping of reamers from sections of a three-cornered file being included. Checking for seed box leakage, causes of cracking of seed, and calibration of the seeding mechanism are also taken up. *(Continued on page 418)*

New Booklet helps take the *Mystery* out of *Motors*

Using electric motors is a new experience for many farm people. Questions, misunderstandings and mistakes are bound to arise unless prevented by accurate information.

The new Westinghouse booklet, "Farm Motors", gives such information in simple, nontechnical language. It illustrates and describes the principal types of farm motors and where to use them. Tables and charts give sizes and types of motors for various machines; estimated hourly operating costs; correct wire sizes and other helpful information. There are complete instructions for making both fractional and integral horsepower motors portable.

A copy is yours for the asking. Send coupon today for this and other Westinghouse booklets of interest.

SEND THIS COUPON FOR FREE BOOKLETS

Please send me free booklets as indicated below:

- ☐ B-2083-A, "Farm Motors"—how to do many farm jobs quicker, better, cheaper with electric motors.
- ☐ Catalog 837-A, "Farm Help from the High Line"—farm and home equipment . . . illustrated with actual farm pictures.
- ☐ B-2215-A, "1940 Guide Book" for National 4-H Club Rural Electrification Contest—helpful suggestions for Club Leaders and contestants.
- ☐ B-2171-A, "How to Make a Toy Motor"—easy-to-follow directions for making a simple motor; interesting, instructive.
- ☐ A-3351, "Light Up and Live on the Farm"—how lighting may be modernized for better farm living and easier farm work.

Name____________________

Address____________________

City__________ State__________

Clip coupon, paste on postal card, and mail to: Westinghouse Rural Electrification, Dept. 236, 306 Fourth Avenue, Pittsburgh, Pennsylvania.

Westinghouse

ELECTRICAL PARTNER OF AGRICULTURE

Agricultural Engineering Digest

(Continued from page 414)

CONTOUR FARMING FOR SOIL AND WATER CONSERVATION. *C. H. Van Vlack and L. E. Clapp.* Iowa Sta. (Ames) Bul. P11, n. ser. (1940), pp. 321-335, figs. 17. Reports from farmers were found to indicate that contour farming lessened power consumption, whereas on terraced fields about an equal number reported increases and decreases in tractor fuel used. The power saving effected by contouring was generally considered to offset any increase in the time required, as compared with cultivation up and down the slope. The soil conserving value of the contour-cropping system is pointed out, and contour cropping is preferred to terracing, because of the greater cost and less convenience of tillage operations on terraced lands, except in the management of lands which must be used for crops and are so subject to erosion that adequate control can only be obtained by terracing.

A simple type of level practical for contour lay-out work has its line of sight across the tops of two liquid columns which are interconnected and so must always be at the same level. A simply constructed "walking A" for laying out contour lines is also described, and its construction is shown in a dimensioned drawing.

THE RELATION OF WALL CONSTRUCTION TO MOISTURE ACCUMULATION IN FILL-TYPE INSULATION, *H. J. Barre.* Iowa Sta. (Ames) Res. Bul. 271 (1940), pp. 509-569, figs. 24. The permeability of numerous wall construction materials with respect to water vapor was determined, measurements being so made as to simulate conditions under which building materials are used. Materials found to be of high permeability are rosin sheathing paper and fiber insulation boards which are not vapor proofed. Those shown to be of low permeability are heavy asphalt-saturated felts and sisal kraft papers. Aluminum paint, applied in two coats, served as a good vapor seal. Other building materials, including plaster, wood, and concrete, were found permeable to water vapor.

Thirty-three test walls, including, frame, brick veneer, double tile, and concrete L-block walls, and uninsulated as well as insulated walls were subjected to controlled conditions of temperature and humidity. A number of the walls were constructed to give wide variation in the water-vapor permeability properties of both the warm and cold sides of the wall to determine the effect of these properties on moisture accumulation. A constant temperature-humidity room was constructed to control the conditions on the warm side of the walls, and mechanical refrigeration was used to maintain low temperatures on the cold side. The conditions maintained were 75 F and 50 per cent relative humidity on the warm side, and a temperature of from 12 to 16 F and a relative humidity of 80 per cent on the cold side. The period of test for different walls varied from 25 to 72 days. At the end of the test period, moisture samples of the insulation were taken, and the inside of the cold side of the wall inspected for free moisture. The frame walls were weighed at intervals throughout the test to observe the rate of moisture accumulation.

In general, the results of the tests on the wall sections also show that to prevent accumulation the permeability of the cold side of the wall must be many times that of the warm side. A water-vapor barrier in the form of two coats of aluminum paint on the inside surface of the wall reduced the rate of accumulation but did not eliminate it. A similar result was obtained with a wall which had a cold face of high permeability. Uninsulated walls accumulated moisture as well as insulated walls. The accumulated moisture was always found on the inside of the cold wall.

SEED PROPAGATION OF TREES, SHRUBS, AND FORBS FOR CONSERVATION PLANTING, *C. F. Swingle.* U. S. Dept. Agr., Soil Conserv. Serv., 1939, SCS-TP-27, pp. [205]. The author presents a tabulation of species useful in soil conservation plantings with pounds of seed per 100 lb of fruit, the number of clean seed per pound, the time when seed should be collected, the cut test and germination test in percentages, the conditions suitable for storage of the seed, treatment of the seed, time of year when the seed should be planted, and the number of useful plants obtained from 1 lb of seed. This information was compiled from various published and unpublished sources, especially from data furnished by the technical staff of the Soil Conservation Service.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE NEVADA STATION. (Partly coop. U.S.D.A. and Univ. Nev.) Nevada Sta. (Reno) Rpt. 1939, pp. 33-35. These have included work of the department of irrigation, by G. Hardman and H. G. Mason, on an inventory and history of the agricultural land resources of the basins of the Truckee, Carson, and Humboldt Rivers and minor streams, reported under the subheads cooperation with Elko County range conservation study and land-classification maps, and on an inventory and history of the water resources of these basins, reported under the subheads tree-ring studies and studies of variation in lake level. *(Continued on page 420)*

Agricultural Engineering Digest

(Continued from page 418)

Agricultural Engineering Investigations at the New Jersey Stations, New Jersey Stas. (New Brunswick) Rpt. 1939, pp. 19, 20, 35, 129-132. These have included poultry housing, the work having been devoted mainly to insulation and protective covering for the insulating material; silos and grass silage, under which head is noted the much greater lateral pressure exerted by grass than by corn silage; studies of temperatures in grass silage, in which it was found that a preservative is necessary and that molasses and phosphoric acid serve this purpose well; farm buildings plan service; and a mechanical blueberry fertilizer distributor, which consists of a combination of an "endgate" centrifugal distributor and a positive feed from a potato planter.

Under the general head of sewage treatment are taken up principles underlying activated sludge process ((1) clarification and (2) enzymes), methods, methane-producing organisms, growth-promoting substances, sewage-clarifying organisms, and properties of hydrated lime. Water treatment, stream pollution, and cooperation with department of institutions and agencies are also reported upon.

Water Control Investigations at the Florida Station, *B. S. Clayton and J. R. Neller.* (Coop. U.S.D.A.) Florida Sta. (Gainesville) Rpt. 1939, pp. 156, 157. Pumping records, work on water-table plats, evaporation studies, subsidence investigations, and the keeping of automatic water-table variation records are noted under this head.

Literature Received

Terracing, by Donald Christy. Paper bound, lithoprint, 172 pages, 8¼x10¾ in, 267 illustrations, exercises, indexed. A text and reference for present and future county agents, teachers of vocational agriculture, and others directing or practicing terracing work. Related subjects are covered only to the extent that they influence mechanical phases of erosion control. Chapters are devoted to introduction, erosion and erosion control methods, terrace and contour staking equipment, terrace and contour spacing, terrace gradient, terrace construction and terracing equipment, terrace outlets, terrace outlet size, farming terraced land, pasture improvement, gully control, land clearing, moisture conservation, and terrace planning. One or two exercises on the subject matter of each chapter are provided at the back of the book. Advanced design data is given in an appendix. Donald Christy, A. and M. College, College Station, Texas. $2.25.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

JUNIOR ENGINEER. The U. S. Civil Service Commission announces an open competition assembled examination for junior engineers in various branches including agricultural engineering. Details are explained in announcement No. 132 (assembled). Applications form No. 8, copies of which may be obtained from any first or second-class post office should be used in applying for this examination and should be on file with the commission at Washington not later than October 24, or if mailed from certain western states, October 28. Other usual Civil Service examination regulations apply.

POSITIONS WANTED

AGRICULTURAL IMPLEMENT BLOCKMAN, with three years in agricultural engineering work at Kansas State College and ten years' experience with large manufacturer of farm equipment desires position with another similar concern, or in any branch of agricultural engineering, farm management, or agricultural bank. Age 36. Health excellent. No defects or bad habits. Married. Rural background. Complete credentials furnished upon request. Best of references. PW-328

AGRICULTURAL ENGINEER with B. Sc. degree from Iowa State College (1938) and M.S. degree from Virginia Polytechnic Institute (1940), desires position with the U. S. Soil Conservation Service. Civil service rating as Junior Engineer. Auto and tractor mechanic. Age 34. Single. Health excellent. Farm background. Complete credentials furnished upon request. PW-329